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ARM-CHEST ADHESIONS

BRACHIOTHORACIC ADHESIONS, AXILLARY WEBS *

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The purpose of this paper is to call attention to the proper treatment of arm-chest adhesions. It is based on a review of the literature and on a study of forty-eight cases hitherto unreported. These may be divided as follows: twenty-five cases in which operation was performed in the surgical clinic of the Johns Hopkins Hospital, by fifteen operators; two at the Children's Hospital School, by two operators; fourteen in which I have operated, and seven cases in which the patients have come to me for consultation, two of whom are now awaiting operation.

The deformities caused by these adhesions, in extensive cases, are among the most serious with which the plastic surgeon has to deal. The affected arm is practically incapacitated, and in young people growth and development are retarded. A disagreeable and not unimportant accompaniment is the fact that the patient is frequently unable to wear ordinary clothes.

I have heard it said that there is no excuse for the occurrence of such adhesions, and that the presence of an axillary web indicates poor treatment. Theoretically, this is true; but when one is called on, either in the home or in the hospital, to deal with an extensive third degree burn of the arm, axilla, chest wall and probably other regions of the body, and the condition of the patient is extremely critical, it being doubtful for a considerable time whether life can be saved, unquestionably it is better to allow the patient to assume the most comfortable position and thereby add a little to the chance of saving life, rather than to increase the pain and shock by insisting on what is known to be the best posture for the prevention of adhesions. When patients with axillary webs come to me I never feel justified in criticizing the early treatment, as the man on the spot may have been called on to make some such decision as I have mentioned above, and may have done splendid work in pulling the patient through at all.

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* From the Surgical Department of the Johns Hopkins University and Hospital.

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SNB

HISTORY

The literature for the last twenty years shows an occasional case report, but little else. The principal contributions were made in the last half of the last century by French authors, among them Jobert,[1] Verneuil,[2] Berger,[3] Defontaine[4] and Piéchaud,[5] and their conclusions were based on the study of one case, or at most two cases, each.

About the middle of the last century, it was recognized that cicatricial tissue could be used in the repair of deformities due to scar contracture, provided it was flexible and that it had sufficient vascularity. On the basis of this fact, several operations have been devised, utilizing the scar web itself, either in whole or in part, for the correction of the deformity. It seems quite remarkable that more has not been written on the subject, and that so little is apparently known about the treatment.

ETIOLOGY

It is an interesting fact that an axillary web may be congenital in origin. This is very rare, however, the case reported by J. B. Manson[6] being the only one I have encountered in the literature. Dr. Whitridge Williams tells me that no such deformity has occurred in the obstetric service of the Johns Hopkins Hospital.

The vast majority of the arm-chest adhesions considered here, and also those reported elsewhere, are the result of third degree burns in which the granulating surfaces are allowed to come in contact with each other and eventually fuse. Arm-chest adhesions are not at all uncommon in this section of the United States, but I understand that these cases are found more frequently in countries where crude methods of heating, cooking and lighting still prevail. Dr. Arley Munson writes me that he treated numbers of these adhesions in the course of his surgical work in India, and Dr. Eleanor Wolf Stewart tells me that she

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1. Jobert, A. J. (de Lamballe): Autoplastie indienne. Thoraco-plastie pour détruire une difformité par bride, Traité de chirurgie plastique, Paris **11**:40, 1849.

2. Verneuil, A.: Cicatrice ancienne, suite de brûlure, occupant une grande étendue de la paroi latérale du thorax et du bras correspondant. Autoplastie par la méthode indienne.—Insuccès.—Nouvelle opération par les coupes angulaires superposées (procédé de Wharton Jones). Amélioration très notable, Bull. et mém. Soc. de chir. de Paris, Dec. 9, 1857, p. 195; Symphyse thoraco-brachiale, Mém. de chir. réparatrice, Paris **1**:643, 1877.

3. Berger, P.: Autoplastie par le méthode italienne modifiée, Seánce Acad. de Med., Nov. 22, 1887.

4. Defontaine, L. (du Creusot): Symphyse thoraco-brachiale, Arch. prov. de chir. **1**:145, 1892.

5. Piéchaud, T.: Deux observations de symphyse des membres à la suite de brûlures étendues, Rev. d'orthop. **7**:81 (March) 1896.

6. Manson, J. S.: A Case of Webbing of the Left Arm, Lancet **1**:1182 (June 4) 1921.

had a similar experience. Most of these patients were children who had been burned by the primitive open lamp of India, which is usually placed on the floor when lighted.

SUMMARY OF CASES (TOTAL NUMBER, FORTY-EIGHT)

Clinical Data.—Cause: Burns with fire were the cause of the condition in forty-four cases; burns with hot grease in one case; roentgen-ray burns in two cases, and slough of a breast flap in one case.

Age in decades: In the first decade there were twenty-eight patients; in the second, ten; third, four; fourth, two; fifth, three, and the sixth, one patient.

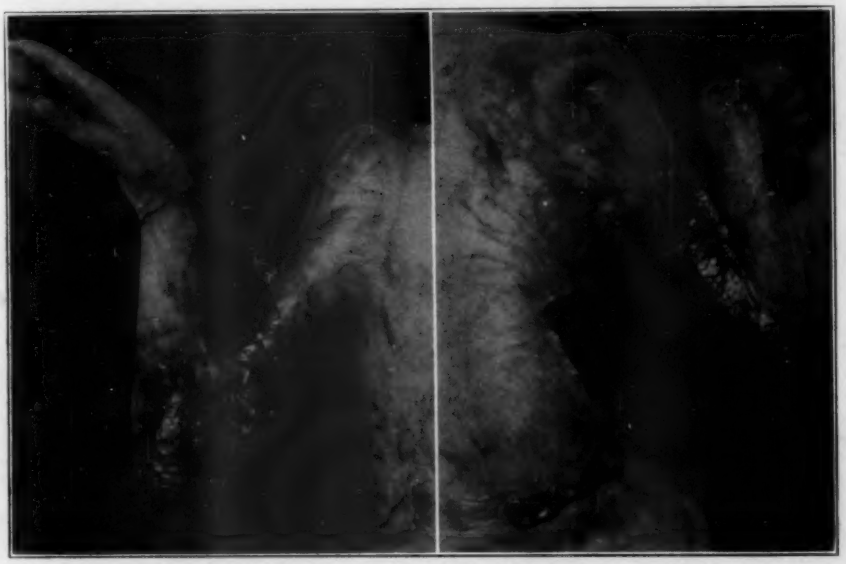

Fig. 1.—Arm-chest adhesions following burns, in a boy, aged 6; of several months' duration. The limits of abduction and the extent of scar and unhealed areas are shown. The axillary and cubital spaces are obliterated and there is marked contracture of the wrist.

Sex: The sex incidence was: male, twenty-three; female, twenty-five.

Side involved: The right side was involved in twenty-eight patients; the left in seventeen; both in three.

Time elapsed since injury: Less than two years had elapsed in thirty patients; up to ten years in thirteen; ten years or over in five. Many types of webs have been found, and no two have been exactly the same.

The patients operated on numbered forty-one. Types of operative procedures may, in a general way, be grouped as: (1) excision of binding scar with suture, four; (2) transverse division with vertical

closure, three; (3) division or excision of the binding scar with autoplastic operation, thirty-four. Complications were: erysipelas, typhoid fever, diphtheria, bronchitis, slough of flaps (partial or complete), partial break down of suture line, partial take or failure of skin grafts and partial recurrence of binding scar. Secondary operations numbered eighteen. The results were: well, twenty-five; improved, sixteen.

Analysis of Cases.—Forty-four of forty-eight were caused by burns with fire. In every one of these, there was more or less extensive scarring in addition to the arm-chest adhesions. The ages varied between 4 and 59 years, there being more cases in the first decade than in all the rest together. The sexes are about evenly divided. White patients predominate, forty-two to five, which is about the proportion of white to colored in Baltimore. Thirty-two patients were examined under two years after injury, twenty-two of these

Fig. 2.—Arm-chest adhesions following burns, in a girl, aged 17; of six years' duration. Left: Extent of abduction, destruction of the nipple and scarring of the breast, and the contracture in the cubital space are shown. Right: The thickened keloidal scar and the scar pocket, which contains axillary skin, are shown. This pocket is 3½ inches (8.7 cm.) deep and admits two fingers.

under one year. Of the remainder, in one the adhesions had been present two and one-half years; in five, three years; in one, three and one-half years; in two, several years; in one each, six, eight, ten, twelve, thirteen, twenty-one and fifty-seven years. The shortest period was several months, the longest fifty-seven years. In the type of operations mentioned, for convenience I have placed under autoplastic operations, thirty-four cases. As a matter of fact, each one of these might be grouped separately, since, while they may be listed under the same general heading, the actual operative procedures differed widely.

In arm-chest adhesions, the result "well" in the hospital history may be misleading, as subsequent investigation often shows that "improved" would be the maximum that could be claimed. On the other hand,

after the relief of the binding scar and after the axilla is formed, what is merely an improvement at discharge may with time and proper manipulation, develop into a good result.

Types of Adhesions.—Axillary webs vary markedly in type from the thin lax membrane which allows considerable motion, to the solid thick mass of scar tissue which obliterates the armpit and glues the arm immovably to the chest wall. These adhesions may vary in extent from a few centimeters to the full length of the arm. The entire

Fig. 3.—Partial recurrence of arm-chest adhesions following the formation of the axilla with small deep grafts. The web is thin and soft, and interferes very little with function. Development is normal. The photograph was taken several years after operation.

axilla may be obliterated or the adhesions may be along the anterior or posterior axillary fold, or both. There are numerous degrees of the deformity, each one of which demands special study, if the best result is to be looked for. The amount of motion possible for the arm and shoulder depends on the vertical length of the web and on its shortness transversely. In other words, the greater the vertical length and the shorter the transverse measurement, the less the motion.

Anatomic Changes.—The anatomy of the parts involved may be materially modified by these extensive deep cicatrices, and great care must always be exercised when the arm is abducted after division of the adhesions lest damage may be done to some deep vessel or important nerve, or even to the humerus itself. In cases of long duration, there is frequently marked atrophy of the bones (humerus and portions of the scapula) and also of the muscles and other soft parts, due to disuse, with the additional factor of pressure from the thick unyielding scar. The atrophied arm is thinner and in some cases the humerus is shorter than in the normal arm. The head of the humerus may be pulled forward by the scar. Underdevelopment of the glenoid cavity and acromion process is occasionally found due to lack of use and

Fig. 4.—Arm-chest adhesions following burns, in a boy, aged 9; of three years' duration. Left: The limit of abduction and the scar on the anterior chest wall are shown. The scarring was even more extensive on the posterior wall. Right: Appearance one year after the division of the adhesions and forming of the axilla with Ollier-Thiersch grafts. The axilla is deep and well formed. There is a partial recurrence of the adhesions in the anterior and posterior axillary folds, which is not an infrequent occurrence when these grafts are used.

continued scar pressure. Often there is contraction of the muscles and of the muscle aponeuroses. Sometimes there is replacement of the muscle tissue by scar. In practically all cases with extensive adhesions between the arm and chest wall, there is marked scoliosis, and this cannot be corrected in any way until the adhesions are released and the scar tension is relieved.

There is distinct limitation of chest expansion on the affected side, and occasionally the ribs are deformed. In the majority of cases, the

burn involves a considerably larger area than the axilla and adjacent portions of the arm and thoracic wall, and in consequence we frequently find other contractures, such as those of the neck and face, the cubital space, forearm and wrist, which may complicate the operative procedure. In several cases which have come under my observation, both axillae have been involved, with more or less extensive webs. Not infrequently, we find dense keloid growths complicating the condition, and I have seen the binding scars entirely keloidal in character.

Preliminary Care.—Every effort should be made to build up the general health of the patient before operation and to raise the hemoglobin to at least 75 per cent. The building up process may be a very slow one in badly depleted cases; but, during this period, if any unhealed area is present, the wound and surrounding tissues can be carefully prepared for future operative work.

When handling children, and many of these patients are children, one must use every effort to gain their confidence and do the dressings without pain. This may seem a minor point, but I have seen children nearly frantic with dread of the next dressing when the last one had been inconsiderately handled. This mental attitude tends to keep patients below par and makes it more difficult to build them up.

When the web has formed and the scar is rigid and adherent, unless it is directly contraindicated I frequently advise a month or two of systematic massage of the entire scarred area, with carefully directed stretching and passive motion. In this way, the circulation is improved, and tissues are softened and can be utilized in the operative work which would otherwise have been entirely unavailable. A keloidal scar may also be made softer and more pliable by careful treatments with radium or the roentgen ray, and in certain cases such treatments are worth a trial before operative work is commenced. I have had no success whatever with fibrolysin.

Preparation of the Part for Operation.—The field is sponged with alcohol followed by ether, and then painted with two or three coats of one-third strength tincture of iodin (stronger iodin is inadvisable on scar tissue). Another excellent method is to paint with a 5 per cent. alcoholic solution of picric acid, after sponging with alcohol followed by ether, and this has the advantage of being nonirritating, although its staining properties are objectionable.

Anesthesia.—General anesthesia (preferably with ether, or gas-ether) must be used in the majority of instances, because when one is dealing with scar, or scar infiltrated tissue whose power to heal is already doubtful, the use of a local anesthetic by the infiltration method is questionable. In this tissue, resistance is lowered and the scanty circulation interfered with by the infiltration, and sutured wounds do

not heal as readily as they would without it. I, therefore, hesitate, when primary union is essential, to use infiltration, but when simple division of the adhesions, or excision of the binding scar without immediate suture, is called for, the method can be used to advantage. Nerve blocking, while possible, is a considerable undertaking for operations of this character, and cannot be recommended. I use for infiltration 0.5 per cent. procain, with from 5 to 10 drops of epinephrin chlorid to each 30 c.c.

Sutures and Ligatures.—In all of these cases, I prefer catgut for ligatures and buried sutures. While silk can be used with impunity in wounds which we know are clean and when normal tissue is being dealt with, I find it safer to use the absorbable material in scar infiltrated tissues, which not infreqently breaks down. For closing the skin, I prefer horse hair and the "on-end" mattress suture. Fine waxed silk is also useful. For tension sutures, silk-worm gut or silver wire gives the best results.

All wounds should be sutured without tension, if possible, and tension sutures should be the exception rather than the rule. When sutures are placed in scar tissue, they should be fairly far apart and should not be tied too snugly.

Asepsis should be maintained throughout the operation and until healing is complete. Tissues should be handled with the greatest consideration, and this applies especially to pedunculated flaps. All hemorrhage should be carefully checked and the area into which the flap or graft is to be transferred should be perfectly dry, as many failures follow the formation of a clot beneath the transplant.[7]

Small protective drains inserted at strategic points under the flap, and removed within forty-eight hours, are often advisable.

TREATMENT

Much has been said concerning the relief of arm-chest adhesions by means of local treatments and various methods of extension; but my experience has been that after the web has formed and contracted fully, except possibly in the slightest grades, nothing promises permanent relief except properly executed surgical intervention.

Incomplete Healing.—I will not consider the preventive treatment, as the plastic surgeon is seldom called in these cases until adhesions have formed and the arm and chest wall are bound together. Sometimes, however, we do see patients reasonably soon after adhesions have

7. In this paper, when I use the term graft, I mean a free transplant; and when I use the term flap, I mean a mass of tissue which is attached at some point of its periphery or base by a pedicle through which its receives its blood supply, and which can be shifted as far as its pedicle will allow.

formed, but before healing has taken place. In such cases, the granulation tissue should be brought into satisfactory condition by the use of surgical solution of chlorinated soda (Dakin's solution) or some other effective treatment checked by bacterial count. Then, under a general anesthetic, all granulation areas are curetted off and it is usually found that the arm can be pulled away from the chest wall without much

Fig. 5.—Berger's web-splitting operation (Berger and Bonset) for the relief of arm-chest adhesions. Left: *ab*, incision dividing the web into two planes; *ac*, incision along chest wall, freeing the anterior plane and forming flap *A*; *bc'*, incision along the arm, freeing the posterior plane and forming flap *B*. Center: Outline of the same incisions seen from below, forming flaps *A* and *B*. Right: Transposition of flaps *A* and *B*.

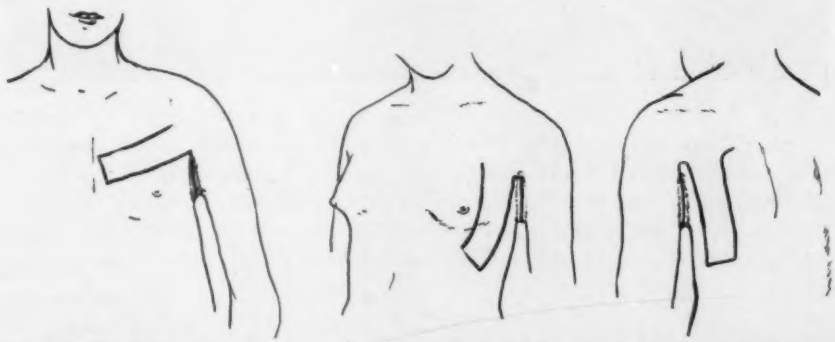

Fig. 6.—Types of operation for the reconstruction of the axilla by the use of pedunculated flaps. Left: Jobert's operation; center: Chaput's operation; right: Berger's operation.

difficulty, and that a definite line of cleavage develops which extends to the top of the axilla. If this does not occur at once, all binding tissues should be divided until the arm is free, and the arm raised at least as high as the shoulder, and higher if it is deemed advisable, and secured in this position. This may be all that can be accomplished at this time; but frequently it is possible to proceed with skin grafting or flap transplantation at once. The use of these methods will be considered later.

Patients occasionally come in with dense adhesions of long duration (several years), but with healing still incomplete. In these instances, as soon as the granulations are properly prepared, epithelization is hastened by means of small deep grafts, and after the lapse of several months, during which time massage is inaugurated, the operative work should be commenced.

Division of the Adhesions.—It is probable that the first operative procedure practiced for the relief of arm-chest adhesions was simple division of the web across the binding portion down to normal tissue. Packing the gaping wound thus made, and keeping it packed until healing by granulation finally took place, was a later development. Simple division may improve conditions somewhat, if the arm is kept fully abducted during the period of healing, but the method is not to

Fig. 7.—Arm-chest adhesions following burns, in a boy, aged 9; of seven months' duration. The wound was healed by small deep grafts before the patient was referred to the author. The limit of abduction is clearly shown. The adhesions were divided and the axilla was formed by means of a large flap from the scapular region and a smaller one from the pectoral region, which were sutured together. All raw surfaces were covered with Ollier-Thiersch grafts.

be recommended, as it is slow and uncertain, and other procedures are better.

Excision of the Binding Scar.—Occasionally, the contracting portion of the scar is of such a character that it should be excised and the defect grafted. Sometimes, instead of grafting, it is possible to close the defect by suturing after undercutting and gliding. If this is done, it may be necessary to make relaxation incisions in order to bring the edges together without tension. These incisions should be made a sufficient distance from the edges to be sutured, so as not to interfere with the blood supply. The defects left by the relaxing incisions may be grafted at once, or subsequently.

Division and Suture of Edges in Lax Webs.—When the web is lax and fairly thin, the adhesion may be relieved by dividing transversely through the scar down to normal tissue and suturing longitudinally. Considerable gain is often made by this procedure. Another method is to make a sinuous incision, or an angled Z-shaped incision or some modification of it, shifting the flaps thus formed and closing so as to lengthen the binding edge of the web. The difficulty with this plan is that the flaps may slough and the suture line break down, as the operative procedure is carried out in scar tissue in which the circulation is precarious. Although some gain is usually made, recurrence at least to a certain extent will invariably follow unless the operation is performed with more than ordinary skill. These methods may be useful in selected cases and should be kept in mind.

V-Incision with Y-Closure.—The method which Wharton Jones [8] used for the relief of ectropion was employed by Verneuil [2] in 1857 on one case, twice in two places, and he reported a good result.[9] The procedure is as follows: A V-shaped incision is made in the selected portion of the scar band down to healthy tissue. The surrounding tissues are undercut, and the flap loosened, and pushed up or down as the case may be, and the closure is made in the shape of a Y. Some gain can be made by this operation, but for the permanent relief of a contracture in this position, unless it is of minor degree, it is seldom successful. However, this method may be used with success in certain secondary operations and should not be forgotten.

Formation of an Epithelial Lined Fistula.—In lax, very thin webs, the formation of a cicatrized fistula high up in the web, based on the method suggested by Rudtorffer [10] in the treatment of syndactylism in 1801, has been used. To accomplish this, the web is perforated as high up as possible, and a glass or rubber tube or some other smooth foreign body is introduced and secured in the opening. After healing is complete, the web is divided up into the fistula, and the lateral edges are closed by sutures. A good axilla can never be formed by this method alone, and simple perforation in my opinion is an undesirable procedure. If, however, this type of operation is chosen, a better method, based on Félizet's procedure for syndactylism, is this: A pedunculated flap of skin and subcutaneous tissue of the desired size, with pedicle above, is raised from the highest portion of the web on the front or back, depending on which side of the skin is least infiltrated with scar.

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8. Jones, Wharton: Principles and Practice of Ophthalmic Medicine and Surgery, 1856, p. 388.

9. This patient was seen some years later, and further operative work was required.

10. Rudtorffer, F. K.: Abhandlung über Operation eingesperrter Brüche nebst einem Anhang, Wien **11**:478, 1801.

A similar flap, with its pedicle below, is raised from the other side of the web. Any soft tissue which remains after raising the flaps is excised. Then the flaps are drawn throught the opening and sutured so as to line the fistula as completely as possible. A piece of gauze fitting the opening snugly is wrapped in rubber protective and drawn through, and then dressings are applied. When healing is complete, the web is divided up into the fistula, and the lateral edges are sutured.

SKIN GRAFTS [11]

In certain instances, when the scar is so deep and so widespread that there is no available adjacent tissue, the only solution of the problem

Fig. 8.—Same patient as in Figure 7, four years later, showing extent of abduction. Function is normal.

seems to be by the use of skin grafts. After the adhesions have been released and the arm has been abducted and secured, the grafts may be applied, either immediately, which is advisable if the tissues are in good condition, or within a few days after granulations have formed, if there is marked atrophy of the soft parts. Three types of grafts are available for this purpose.

Small deep grafts are the least effective for the lining of the axilla, because there is more scar tissue formed between these grafts

11. Davis, J. S.: Technic of Skin Grafting, Plastic Surgery, P. Blakiston's Son & Co., Philadelphia, 1919, p. 49.

than in other types, and consequently more subsequent contracture. However, this type of graft is effective in filling in raw surfaces on the chest wall and arm, and may be very useful as a temporizing procedure in the axilla.

A much more satisfactory type of graft for this purpose is the large, thin Ollier-Thiersch graft. The axillary space can be completely covered with one or more of these grafts and all other raw surfaces as well. The subsequent contracture is much less than when small deep grafts are used, and a high and in some instances a well-formed axilla can be made. Recontracture, especially along the anterior and posterior axillary folds, is prone to occur, but can be relieved with comparative ease by appropriate secondary operations.

The best type of graft to form the axilla is the whole thickness (Wolfe-Krause) graft. It is obvious that an axilla lined with skin of full thickness which is soft and has the qualities of normal skin, and which has little tendency to contract, is better than either of the types previously mentioned. On account of the greater operative procedure and the comparative unfamiliarity of most surgeons with this type, whole thickness grafts have been used very infrequently for lining axillae. Sometimes it is advisable to form the apex of the axilla with whole thickness grafts, covering the other raw surfaces with either Ollier-Thiersch or small deep grafts.

PEDUNCULATED FLAPS

When the axilla is obliterated, and the upper portion of the arm is bound to the chest wall, numerous methods of utilizing flaps to reconstruct the armpit have been described. These flaps may be composed of scar or scar infiltrated material, of scar and normal tissue or entirely of normal tissues, the choice depending on the condition of the surrounding tissues. Normal tissue alone is, of course, to be preferred, if available.

Flaps Composed Partially or Entirely of Scar Tissue.—Berger's operation (1887)[3]: Berger devised an operation in which he split the web and readjusted the flaps, somewhat after the method used by Didot for syndactylism. His method is as follows: Along the lower margin of the web, an incision is made following the center of the fibrous arch joining the arm and the chest wall, thus separating the web into two planes, one anterior and the other posterior. The separation is carried up between the planes to the apex of the axilla and out on the sides as far as necessary. The anterior plane is then raised and separated from the trunk by an incision which follows its line of junction with the thoracic wall and extends to the top of the axilla, thus making a triangular flap with its base along the arm. The same pro-

cedure is carried out on the posterior plane, the incision on this side being made along the arm, the base of the flap being along the chest wall. The arm is then raised and the flaps are shifted, the anterior to cover the raw surface on the arm, and the posterior to fill in the loss of substance on the chest wall.

Berger says that this method can be used with success in the majority of instances. I cannot agree fully with this statement. I have found it satisfactory in certain cases in which the web is lax, but as the flaps are composed entirely of scar tissue, they are liable to slough, at least in part. However, if only a part of each flap retains its vitality, the condition may be materially improved; and, by secondary operations, full function can eventually be restored.

Defontaine's operation (1892)[4]: Defontaine (du Creusot) devised an operation based on a modification of the principle used by Félizet

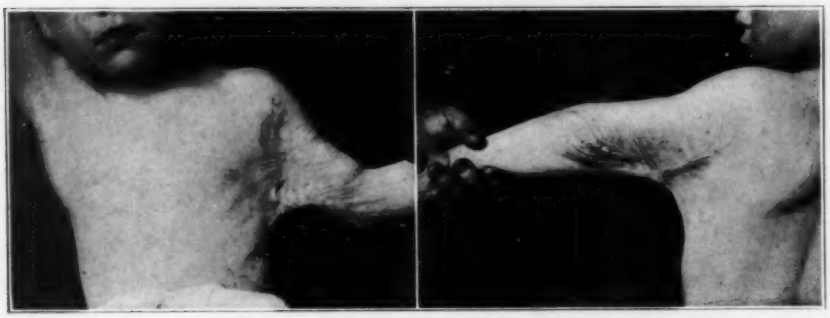

Fig. 9.—Arm-chest adhesions following burns, in a boy, aged 4, of ten months' duration. The extent of abduction is shown. There is normal skin available for flaps on both front and back.

for the formation of a commissure between the fingers. This can be done by the use of either square flaps, or angular flaps united obliquely, which he prefers. He makes a vertical Y-shaped incision on front and back, the arms of which begin in the normal skin just above the level of the apex of the axilla and meet at about the middle of the web. The V-shaped flaps included between these incisions are dissected up, and the Y is completed by dividing the web in its midline. All adhesions are then separated and the arm is raised. The flaps are then turned in, to form the axillary commissure, the anterior being inside and the posterior outside, and the edges are sutured, meeting each other obliquely. All raw surfaces are then filled in as well as possible by suturing. It must be remembered that, even under the most favorable conditions, the tip and central part of each flap is composed of scar tissue whose circulation is doubtful. Moreover, the closure of raw

surfaces by shifting tissues is difficult unless the surrounding skin is in fairly good condition. However, skin grafting can be used to fill in these defects.

Piéchaud's operation (1896)[5]: Piéchaud raises two large triangular flaps, the anterior with its base in the pectoral region and the posterior with its base in the scapular region. The free ends of both include a portion of the web. All adhesions are divided and the arm is raised. The flaps are then turned in, to form the axilla, the anterior flap being above the posterior (when the arm is fully abducted). All other raw surfaces are covered by suturing the edges. This procedure is an improvement over that of Defontaine as the flaps are larger and the blood supply is better. This operation also depends for its success on the presence of normal skin adjacent to the web.

Flaps Composed of Normal Tissue.—Jobert's operation (1849): Jobert (de Lamballe)[1] seems to have been the first to perceive the necessity of lining the axilla. In his operation, the web is divided and the arm is abducted. A transverse flap of sufficient length and breadth is raised from the chest wall above the breast, with its pedicle above the axillary fold, and is turned to line the axilla. It is sutured into place, and all other raw surfaces are closed, if possible. Skin grafting, which was unknown at that time, is very useful for covering the raw surfaces which cannot be closed by suture.

Chaput's operation (1904)[12]: Chaput's operation is similar to that of Jobert except that a vertical flap is raised from the skin of the breast and chest, which has its pedicle above, on the level with the top of the axilla.

Berger's operation (1904)[13]: Berger, in extensive cases in which the splitting of the web will not answer for the formation of the axilla, utilizes in women a flap very similar to that of Chaput; but in men secures his flap from the scapular and subscapular regions with its base above, on the level with the apex of the axilla. In all of these operations, the adhesions are divided and the arm is completely abducted before the flap is turned in to form the axilla. Theoretically, all of these methods can be used if normal tissue is present, but if there is extensive scar involvement on the chest wall, both front and back, the success of such flaps is far from sure.

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12. Chaput, H.: Symphyse thoraco-brachiale consécutive à une brûlure; autoplastie à grand lambeau, bon résultat; guerison rapide de la surface ulcérée par les pansements au peroxyde de zinc, Bull. et mém. Soc. de chir. de Paris **30**:604, n.s., 1904.

13. Berger, P., and Banset, S.: Traitements de déformations consécutives aux cicatrices vicieuses de l'épaule, Chir. Orthop., Paris, 1904, p. 180.

Croft's operation (1884) [14]: Croft was successful in relieving an extensive lax axillary web by delayed transfer, using a double pedicled flap of skin and subcutaneous tissue, 8 by 2.25 inches (20 by 5.6 cm.), raised from the deltoid region and arm. The lower pedicle was divided after sixteen days and the free end of the flap was shifted, being turned on its upper pedicle and sutured into the defect made by the division of the web down to healthy tissue beneath. He emphasized the fact that the flap should be "taken free of scar tissue and well supplied with blood." As there is frequently extensive scarring of the arm and shoulder, this method can be employed in very few cases; but even in those, if normal tissue is available in the pectoral or scapular regions, flaps from these are preferable for forming the axilla.

Fig. 10.—Same patient as in Figure 9, five years after formation of the axilla with two square-ended pedunculated flaps from the pectoral and scapular regions, which were sutured end to end. A slight scar can be seen at the line of suture. Raw surfaces were grafted. The normal axilla may be compared with the reconstructed axilla. Function is perfect.

I have found [15] that when we have a lax web involving the anterior or posterior axillary fold, or the axilla itself, one of the operations mentioned above for lengthening the binding edge, or transposing scar flaps to line the axilla, may be used with success. If normal tissue is available, the web may be divided or excised, at least in part, and the continuity of the scar may be broken by the employment of normal

14. Croft, J.: Plastic Operations on the Neck and Arms for Severe Cicatricial Deformities After Burns, Med.-Chir. Tr., London **72**:349, 1889.

15. Adhesion Between the Arm and Chest Wall, in Davis, J. S.: Plastic Surgery, p. 628.

tissue to fill the gap. I might say that, in many cases of scar lengthening, secondary operations are required to correct postoperative contracting bands.

When the adhesions are thick and obliterate the axillary space, my experience has been that the use of pedunculated flaps is the procedure of choice. A single flap either from the chest or scapular region, with its pedicle above, may be sufficient to line the axilla. Two flaps, one from the front and the other from the back, are usually required, the free ends being sutured together. Occasionally, it is advantageous to form the axilla with a flap having a pedicle of subcutaneous tissue. The type, shape and size of the flap must necessarily vary according to the condition and location of available well vascularized tissue.

When there is absolutely no tissue available for flaps, and grafts are considered inexpedient or have failed, then one must think of shift-

Fig. 11.—Arm-chest adhesions following burns in a boy, aged 8; of four years' duration. There is marked atrophy of the bones and soft parts following disuse and scar pressure. The arm and forearm are shortened. The extent of the scar on the front, back and arm is shown. There is a deep transverse scar across the upper third of the arm, also a scar in the cubital space. The dotted line indicates the size and shape of the single anterior flap used to form the axilla. The raw surfaces were grafted.

ing a flap from a distant part by "successive migration." For instance, a tube flap of the desired size can be raised wherever the tissue is available. One end is eventually grown into a prepared defect on the normal forearm or wrist. In due time, the other pedicle is cut, the web is divided completely, the forearm with the flap is brought across the body and immobilized, and the free end of the flap is sutured into the desired position to form the axilla. Subsequently, the flap is cut away from the forearm and the pedicle is utilized where needed. This is only one of many maneuvers to accomplish the same purpose.

In cases in which the surrounding tissue is unsuitable for the formation of flaps, skin grafting must be resorted to.

DRESSING

It is difficult to recommend any single type of dressing after these operations, as the choice depends largely on the operation performed. In the majority of instances, the arm is abducted at least as high as the shoulder, and in some over the head; and it is usually immobilized by means of a suitable splint or plaster cast.

If the operation is a readjustment of the binding scar with suture, then any of the ordinary wound dressings, such as silver foil, can be used. If there has been a reconstruction of the axilla with flap shifting,

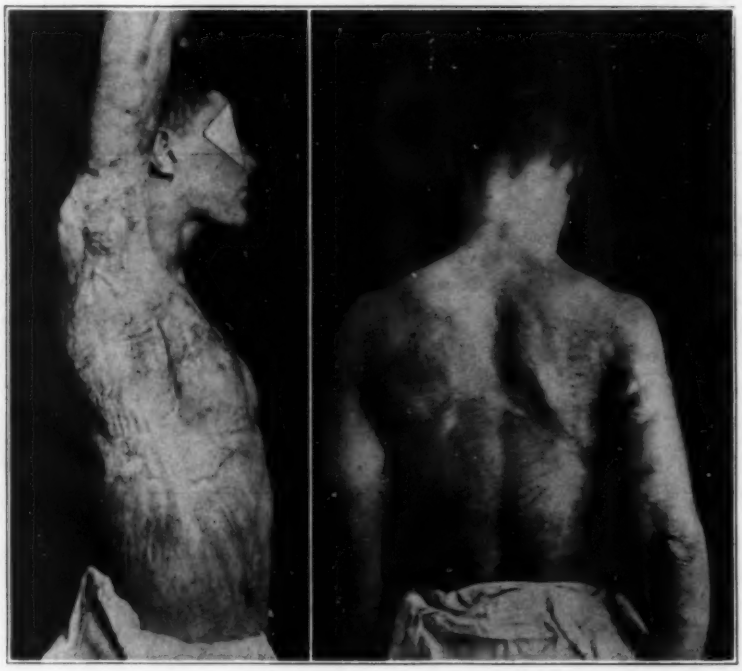

Fig. 12.—Same patient as in Figure 11, eight years and three months after operation. The extent of abduction is shown. The affected arm has not yet attained normal development, although function and strength are apparently normal. The healed area has a patchwork appearance.

or skin grafting, or both, we must use some type of dressing which will hold the transplanted tissues in absolute contact with the new bed and insure a high axilla. A single thickness gauze saturated with petrolatum over the newly formed axillary space, a moist sea sponge cut to fit the cavity, and over this gauze properly secured, is efficacious in obtaining contact of either grafts or flaps here or elsewhere. Grafts on the arm or chest wall may be secured by rubberized or paraffined mesh, over which is placed any dressing desired, and the whole

immobilized by adhesive plaster and crinoline bandage. In some instances, when the new axilla is formed of flaps with good circulation, the space may be filled with a sea sponge, or gauze as suggested above, and after proper dressing of sutured or grafted areas on arm or chest, the elbow may be lowered and immobilized as in a radical breast case.

POSTOPERATIVE TREATMENT

The patient should be placed on an adjustable bed in the most comfortable position possible. The dressings should be put on by the surgeon himself or under his direct supervision, as good results in a large measure depend on skilful and judicious after-treatment. The type of dressing and the materials used vary according to the requirements of the wounds.

Flaps should be inspected frequently in order to relieve dangerous tension and combat infection, or to evacuate any fluid which may col-

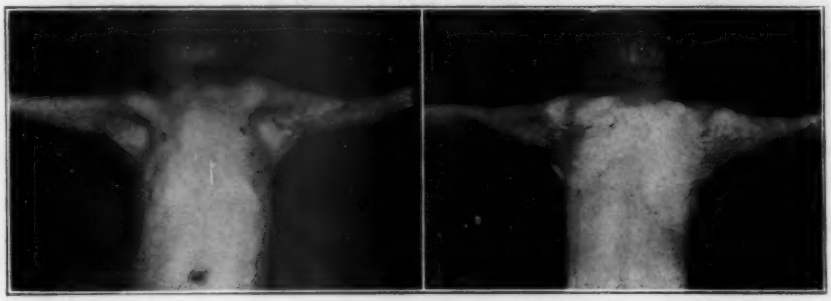

Fig. 13.—Bilateral arm-chest adhesions following burns, in a boy, aged 4, of three years' duration. The webs were divided, the scar tissue was undercut and the flaps were transposed.

lect. If congestion of the flap occurs, it can best be relieved by gentle stroking with the finger tips *toward* the pedicle. Sometimes this must be kept up continuously for the first few hours, until the return circulation is established. Small wet cups will occasionally aid in saving a congested flap. Compresses saturated with warm physiologic sodium chlorid solution at a temperature which will be quite harmless on the normal skin will often cause blistering of the flap and must be used with care. If no circulatory disturbance occurs, the flap is treated as any other sutured wound. I usually begin to remove the stitches on the fifth or sixth day, and have them all out by the tenth or eleventh day.

If skin grafts are placed on a fresh wound and there is no apparent trouble, it is not necessary to disturb the dressing for a week or ten

days. If, on the other hand, the grafts have been placed on a granulating surface, they should be dressed in forty-eight hours, and every day thereafter until healing is complete.

In those cases in which the arm is put up in the abducted position at the operation, it should be held in this position until healing is complete. Then it should be gradually lowered to the side, and passive motion and massage commenced. The cooperation of the patient is essential in the various stretching exercises in order to get the full benefit of the treatment.

During the day, the arm may be allowed to hang at the side; but at night, for a period of several weeks, it is advisable to have it returned

Fig. 14.—Same patient as in Figure 13, twelve years and six months after operation. The extent of abduction, satisfactory condition of the axillae and physical development are shown.

to the abducted position. In those cases in which the arm has not been put up in the abducted position at operation, as soon as healing is complete, abduction must be gradually obtained; and at night, the arm should be secured in the abducted position, as mentioned above. This maneuver, while irksome, will in the end save time and prevent recontracture.

In extensive cases of long duration, in which there has been atrophy of the bone and soft parts due to disuse and scar pressure, the shoulder, arm and forearm have to be practically reeducated after the release of the adhesions. Considerable time may elapse before full function can

be restored, but this can be shortened materially by massage and passive motion. In some instances, the natural contours are never restored, and the humerus never attains its full development, although function is apparently normal.

COMMENT

The operator who has had little dealing with scar tissue contractures and adhesions frequently underestimates the liability of recurrence, and is inclined when relieving webs to use procedures which a more experienced man knows to be inadvisable. The choice of procedure in many instances is not easy.

The treatment of arm-chest adhesions would be comparatively simple if we always found the skin adjacent to the web normal or even slightly infiltrated with scar tissue. The division of adhesions and the release of the arm from the chest wall as a rule is more or less simple; but the prevention of the reformation of the adhesions may be difficult.

The treatment of these cases is not cut and dried, as each deformity presents certain difficulties which are not found in others. Each case must be worked out on its own merits, the methods chosen for its relief depending on the condition of the surrounding tissues, the extent and type of the web, etc. The contemplated plan of attack, based on the ultimate result desired, must be carefully studied. The size and shape of the flaps should be definitely determined and marked out, as well as the lines of incision.

If the vascularity of the flap seems adequate, then it may be shifted at once; but if it is doubtful, delayed transfer should be chosen. The pedicle of a flap may be either above or below the level of the axilla depending on the condition of the surrounding tissues; for instance, in front the pedicle may be above, and in the scapular region below, or vice versa. Sometimes the flap lifted to form the axilla proves to be too short to line the space completely and no tissue is available for a second flap to suture to it. The deficiency may be filled at once by a skin graft, preferably of the whole thickness variety; but if this is unsuccessful, the flap may be further utilized thus: After healing is complete, it can be raised again, and will be found to stretch considerably further than was possible when it was first transplanted, without jeopardizing its circulation. Another method is to divide the original pedicle, and slide the flap on its new base.

In dealing with these cases, a knowledge of the resistance and utility of tissues more or less infiltrated with scar is essential, as normal tissue is usually unavailable.

There is frequently astonishing retraction of the tissues after division of the cicatrix, as the scar itself retracts and the stretched

normal skin attached to the scar also retracts. When the scar is widespread and deep, the problem is much more complicated, and flaps must be shifted in from parts at a distance, or skin grafts must be used.

The surgeon undertaking these cases must be skilled in the technic of skin grafting and be able to utilize any type which may be necessary, as skin grafts are used in some stage of the operative treatment in the large majority of cases. All the principles of tissue shifting and of the use of pedunculated flaps must be well known to the surgeon, as every resource may have to be taxed to secure a successful result.

In extensive cases of long duration, with immobilizing adhesions and much atrophy of the bones and soft parts, it is safer not to raise the arm higher than the shoulder at the time of operation on account of possible injury to vessels, nerves or even to the humerus itself. Full abduction can easily be obtained later, after the tissues have stretched.

In several extensive cases, I have found a rigid, thick, depressed band of scar on the outer side of the arm, about on the level with the insertion of the deltoid muscle. This contracts transversely, markedly compressing the soft parts beneath it, and seems actually to grasp the shaft of the humerus. It is expedient to divide this band longitudinally down to normal tissue, extending the incision well above and below the stricture, whereupon the incision gapes widely and the soft parts bulge out when relieved of the scar pressure. This area is then grafted immediately, if the appearance of the atrophied tissues warrant it; otherwise, it is grafted in a few days, when the circulation is improved.

Sometimes we find patches of comparatively normal hairy axillary skin drawn by the scar entirely away from its original bed; or it may be buried in a deep pocket in the scar, which has a rigid purse-string-like opening. If possible, this skin should be utilized and replaced in its normal position.

After the operative work has been completed, the healed area may present an irregular patchwork appearance. This is of little importance, however, if the axilla is reconstructed; if scar pressure is relieved, and if function is restored. It may be necessary to divide muscle aponeurosis and muscle tissue when contracture is marked and abduction cannot otherwise be obtained. If subcutaneous fat is available, it is advisable to shift it under suture lines, especially if the skin is infiltrated with scar. In certain severe cases, I have found it advantageous to do the operative work in stages, planning for the patient to go home between the steps, in order that nature and time may aid as much as possible.

The operative methods and suggestions mentioned are useful in the treatment of these cases, and either alone or in combination may be helpful in the solution of problems, some of which it requires all the skill of the surgeon to solve. The patient should be warned of the pos-

sibility of more than one operation being necessary to effect a cure. These patients should be followed up systematically after discharge from the hospital, and should report for examination at least every three months until final discharge.

CONCLUSIONS

Arm-chest adhesions are not uncommon.

In the majority of instances, they are the result of third degree burns.

The object of the treatment is, primarily, the restoration of the function of the arm, with the relief of the deformity, and the prevention of recurrence. The successful reconstruction, or readjusting, of the axillary space (armpit) is the key to the relief of the condition.

There is no single operative procedure which is applicable to the treatment of all types of axillary webs.

It is seldom that the deformity, if in any way extensive, can be relieved by one operation; in fact, in nearly all cases, several operations are necessary to restore function completely; and in each one of the secondary operations, new problems are presented, which may require different methods of attack.

The only test of the efficiency of any of the operations used for the relief of arm-chest adhesions is time, and the ultimate result should not be recorded until at least one year has elapsed after the final operation.

THE MONO-OSTEITIC TYPE OF PAGET'S DISEASE OF BONE (OSTEITIS DEFORMANS) *

REPORT OF THREE CASES

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In 1876, Sir James Paget [1] reported before the Medical and Chirurgical Society of London five cases of a rare and strange malady of the bones, to which he gave the name "osteitis deformans." Since that time, it has come to be known as commonly by his own name as by the one which he gave to it.

Forty-seven years have elapsed since that time and yet the literature yields us only about 250 cases which may be definitely recognized as Paget's disease of bone. Thus, in contrast to what we usually find after a careful and accurate description has been made of some disease entity which has before escaped our recognition, it still merits the descriptive adjective "rare." Cutler [2] found seven in 285,000 outpatient admissions at the Massachusetts General Hospital between 1903 and 1915; Hurwitz,[3] only three in 30,000 medical admissions to the Johns Hopkins Hospital; Da Costa, Funk et al.,[4] three in 38,000 admissions to the Jefferson Hospital in seven years, and Carman and Carrick [5] fifteen cases in 237,000 admissions to the Mayo Clinic in six years. In 40,000 admissions to the Peter Bent Brigham Hospital in ten years, there are seventeen cases so diagnosed.

The cases on record in which the typical lesion of Paget's disease may be found affecting only one bone in the entire skeletal system

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* From the surgical clinic of the Peter Bent Brigham Hospital.

1. Paget, J.: On a Form of Chronic Inflammation of Bones (Osteitis Deformans), Med.-Chir. Tr. **60**:37, 1876; Additional Cases of Osteitis Deformans, Med.-Chir. Tr. **65**:225, 1882.

2. Cutler, E. C.: Sir James Paget and Paget's Disease, Boston M. & S. J. **174**:187 (Feb. 10) 1916.

3. Hurwitz, S. H.: Osteitis Deformans, Paget's Disease: A Report of Six Cases Occurring in the Johns Hopkins Hospital and Dispensary, Bull. Johns Hopkins Hosp. **24**, No. 271, 1913.

4. Da Costa, J. C.; Funk, E. H., et al.: Osteitis Deformans; a Report of Five Cases, with Complete Metabolism Studies in Two Instances and a Review of the Literature, Bull. Jefferson Med. Coll. & Hosp., Philadelphia **6**:1, 1915.

5. Carman, R. D., and Garrick, W. M.: The Roentgenologic Aspect of Osteitis Deformans, Paget's Disease, with Reports of Fifteen Cases, J. Radiol. **2**:7 (April) 1921.

comprise a very small percentage of all reported. It seems somewhat questionable to us whether we are justified in calling these anything more than very early cases of generalized osteitis deformans. We are aware that the hope of accurate and proven diagnosis becomes infinitely more difficult and far more open to question when we must blot out of the picture the vivid and absolutely characteristic appearance which multiple bony involvement gives the patient. There is nothing quite comparable to the latter. There are many single bone lesions which may well be confused with osteitis deformans when it occurs in an isolated bone. It is even questionable whether either roentgenograms or pathologic sections can establish to every one's satisfaction the diagnosis of Paget's disease.

The first reliable report of the mono-osteitic form we owe to Sir Anthony Bowlby,[6] who described in 1883 a case of osteitis deformans which was localized in the right femur only. The diagnosis here was based on necropsy findings and seems indisputable.

Schmidt [7] had reported a case in 1874 which showed clinically an involvement of first the right femur and later the left tibia, neither lesion being present at the time of the other. However, no anatomic studies were ever made to confirm the diagnosis.

In a paper [8] on the subject published in June, 1914, Hurwitz reviews the available literature on the single-bone type of Paget's disease, and found in addition to the two cases above, one reported by Edmunds,[9] one by Schmieden,[10] one by Katholicky,[11] and two by Schlesinger.[12] Besides these, there were a number of cases which on account of the lack of either pathologic or roentgen-ray findings must be considered unproved. These included the cases collected from the literature by Czerny [13] (Mosetig, Scoutetten, Solly, Weinlechner), and those of

6. Bowlby, A. A.: Two Cases of Curvature of the Femur, One Due to Osteitis Deformans, the Other to an Injury Followed by Chronic Inflammation, Tr. Path. Soc., London **34**:192, 1883.

7. Schmidt, B.: Ein Fall von Ostitis deformans, Arch. f. Heilk. **15**:81, 1874.

8. Hurwitz, S. H.: Osteitis Deformans (Paget), Involving a Single Bone: Report of a Case, Am. J. M. Sc. **147**:855, 1914.

9. Edmunds, W.: Osteitis Deformans Affecting a Single Bone, Illus. M. News **2**:180, 1889.

10. Schmieden, V.: Beitrag zur Kenntnis der Osteomalacia chronica deformans hypertrophica (Paget), Deutsch. Ztschr. f. Chir. **70**:207, 1903.

11. Katholicky: Wien. klin. Wchnschr. **18**:619, 648, 1905.

12. Schlesinger, H.: Paget'scher Knochenkrankheit (Mono-osteitische), Mitt. d. Gesellsch. f. inn. Med. u. Kinderh. **6**:61, 1907; ibid. **7**:99, 1908.

13. Czerny, V.: Eine lokale Malacie des Unterschenkels, Wein. med Wchnschr. **23**:894, 1873.

Volkmaun,[14] Gliner[15] and Patschu.[16] As Hurwitz[8] quite properly points out, without a convincing clinical history and technical or laboratory studies one is left no choice other than to place them among the doubtful cases. Again, in 1915, Hurwitz and Carr,[17] then of this clinic, reported another case involving the right tibia, substantiated by roentgen-ray studies.

Since that time, we have been able to find instances reported by de Massary and Lechelle,[18] Leri[19] and Romer.[20] Oettinger[21] also mentions a case which he had observed.

De Massary and Lechelle's patient was a woman, 55 years old, of good history, childless, with a lesion of the right femur of ten years' duration. When 30 years old, she had had an arthritis of the knee of unknown etiology. The changes in the femur did not appear until she was 45. At that time, she noticed a curving of the upper leg, which showed by roentgen-ray bony changes characteristic of Paget's disease, with considerable exaggeration of the normal curve of the bone. Nothing was found in any other bones of the body. The Wassermann reaction was negative. Mercury treatment effected no change. There were no stigmas of early senility.

This case was presented before the Société Médicale des Hôpitaux de Paris[18] as a possible case of osteitis deformans localized in one long bone. In the course of the discussion, Oettinger[18] mentioned that he had seen such a lesion localized in the left humerus. He called attention to the fact that in his case trauma might have been the starting point of the trouble. This was also the case in Leri's[19] patient, a brakeman on a railroad who badly bruised his left arm, showing considerable periarthritis of the scapulo-humeral articulation later, and suffered an involvement of the humerus eight months after the accident.

In this connection, it is interesting to note that the three cases reported by Romer[20] all had a definite traumatic origin. These cases he presents as questionable osteitis deformans, recognizing that "in true

14. Volkmann, R.: Spontane Malacie und Verbiegung des Unterschenkels, Beitr. z. chir., 1875.

15. Gliner, S.: Ueber Ostitis deformans (Paget). Dissertation, Beru., 1910, Rosch & Schatzmann, p. 44.

16. Patschu, L.: Ueber deformirende Ostitis, Dissertation, Berlin, O. Francke, 1880.

17. Hurwitz, S. H., and Carr, G. L.: On the Monoosteitic Form of Paget's Disease of Bone, Am. J. Roentgenol. **2**:755, 1915.

18. De Massary and Lechelle: Maladie osseuse de Paget localisée à un seul os long, Bull. et mém. Soc. méd. d. hôp. de Paris **44**:134 (Jan. 30) 1920.

19. Leri, A.: Discussion à propos de la communcation de MM de Massary et Lechelle. Maladie osseuse de Paget localisée à un seul os long, Bull. et mém. Soc. méd. de hôp. de Paris **44**:350, 1920.

20. Romer, F.: Osteitis Deformans? Lancet **1**:77 (Jan. 8) 1921.

21. Oettinger: Discussion, Bull. et mém. Soc. méd. d. hôp de Paris **44**:136, 1920.

Paget's the origin is obscure and injury not mentioned as a factor. Pain, which is practically negligible in cases described by Paget, in all three cases under discussion has been severe." In two of these cases, the lesion was in the tibia and in the third in the jaw bone. Sir W. Arbuthnot Lane,[22] who operated on the first two, "sees no reason to call the condition osteitis deformans, since its clinical history is quite distinct."

In another communication, Leri,[19] commenting on the roentgenograms of de Massary and Lochelle, recognizes their similarity to true Paget's disease, but says also that "one cannot always seize upon the beginning in a single bone, as Paget's disease has so slow a development." In illustration of this theory, he quotes a case observed by himself in which there was some pain in the tibia at 33 years, a definite lesion with deformity of this bone at 52 years, a deformity of the radius at 63 years, and of the other tibia at 62 years, and at 80 years, these three bones were still affected. In favor of single bone lesions, however, he mentions a soldier seen during the war who had an enormous bowed clavicle, without syphilis and without pyogenic infection, which could not be diagnosed as other than osteitis deformans localized to that one bone.

Da Costa, Funk et al.[4] describe three types of Paget's disease: "(1) that in which the first symptoms are vague pains in extremities or back without bony deformity anywhere; (2) that in which there is a local bony deformity usually in the tibia or skull without pain or inconvenience, and (3) that in which subjective and objective phenomena mark the onset and the patient appears complaining of vague pains. Examination reveals the bony defects." We conclude, therefore, that these writers do not recognize the mono-osteitic form as anything but an early manifestation of true Paget's.

We must, therefore, recognize that mono-osteitic Paget's disease may not rightly be a definite subdivision of the clinical entity so clearly described by Paget, but only a very early stage of the generalized type. There is good authority on the other hand for the former view. Schlesinger[12] feels definitely that all localized forms of the disease should be placed in one group, to be known as mono-osteitic Paget's disease. This form he concisely describes as "beginning insidiously without trauma (without a history of syphilis), may continue for years without attracting the patient's attention, and is usually discovered accidentally."

The following case reports are presented because (1) they seem clearly to fall in his rare group and, (2) until more available data is

22. Lane, W. A.: Observations, Lancet **1**:77, 1921.

Fig. 1 (Case 1).—Variation in size with outward bowing of left leg is evident.

added to the meager literature on this subject, we can never arrive at any more definite classification of these interesting single bone lesions.

The three cases here reported were all seen at the Peter Bent Brigham Hospital. The first patient came under observation on the surgical service in May, 1920. Cases 2 and 3 were reported to us by Dr. Sturgis and Dr. Cutler, from whose private practice they were taken.

REPORT OF CASES

CASE 1.—*History.*—F. M., white, a man, aged 46, married, meat cutter, born in Switzerland, admitted, May 15, 1920, complaining of severe pain in the right upper quadrant, was one of eleven children. Both parents died at the age of 60, the mother of cancer of the stomach. The patient married at the age of 24 years, and had three children. There had been three miscarriages. None of his family had shown any symptoms of an affection similar to his own.

Aside from measles, frequent colds during the winters, attacks of lumbago at intervals, and an infected finger ten years before, the personal history was

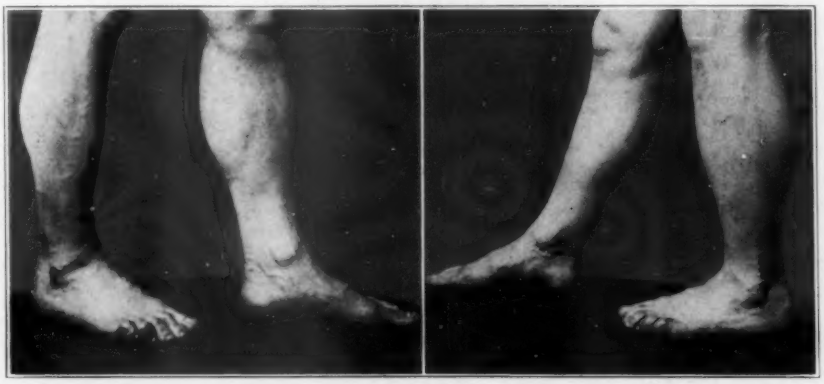


Fig. 2 (Case 1).—*A*, left lateral view. Massiveness of left leg, also anterior bowing are evident; *B*, right lateral view of lower extremities.

negative. One year before admission, the patient had an attack of severe, upper right quadrant pain, radiating to the back and lasting six hours. There were five similar attacks before he came to the hospital, one with slight jaundice and all necessitating morphin for relief.

A diagnosis of gallbladder disease was made, and at operation an adherent gallbladder, with two stones in the cystic duct, was found. He made a splendid recovery, and was discharged on the twentieth day after operation.

During the routine physical examination, a definite swelling of the upper third of the left tibia was noticed. Careful questioning elicited the following history: Six years previously, he struck the left shin, sustaining a slight abrasion which lasted for a few days. There was no disability. It was with some difficulty that he recalled this incident. Two years previously, he noticed that his leg began to feel tired after he had stood at work all day. This led him to rub it. He then noted for the first time a painless swelling of the leg just below the knee, with a slight bowing. Unusual exertion, such as running for a car, caused a slight ache, which continued for a number of hours.

These are the brief facts connected with the lesion about which we are most concerned, considered by the patient as too minor to be dignified by the name of "complaint."

Physical Examination.—The general physical examination was absolutely negative except for slight tenderness in the upper right quadrant and the enlargement and bowing of the left tibia. The patient was exceptionally well set up and active for a person of his age. His height was 5 feet 6 inches (1.67 meters) and his weight 169 pounds (76.6 kg.).

A careful examination was made of the skeletal system. The posture was erect with no suggestion of a stoop. The arms hung normally, reaching to just above the midthigh. Neither the head as a whole nor the features alone showed any undue prominence.

Thorax: This was broad and deep, not barrel shaped, the axillary circumference measuring 38¾ inches (98 cm.). There was no kyphosis. The clavicles were not unduly prominent.

Pelvis: The bony pelvis measured 12 inches (30.5 cm.) between the iliac crests and 11½ inches (29 cm.) between the iliac spines, and the intertrochanteric diameter was 13½ inches (33.8 cm.). There was 2¼ inches (5.6 cm.) between the border of the ribs and the iliac crests. The pelvis as a whole was neither broader nor heavier than normal.

Upper extremities: Neither of the arms showed any excessive thickening or limitation of motion. Their full spread measured 67 inches (170.2 cm.)

Lower extremities: The right leg appeared to be normal in every respect. Both legs measured 33 inches (83.8 cm.) from anterior superior spine to internal malleolus, and 35 inches (88.9 cm.) from umbilicus to the same point. Both upper legs were also similar, measuring 19¾ inches (50 cm.) from the anterior superior spine to the internal condyle of the femur. Motions in all directions of both legs were quite unlimited and painless. The skin over the upper part of the tibia was slightly more glossy and smooth on the left than the right. With the malleoli in apposition, the left knee projected 1 inch (2.5 cm.) beyond the right. There was 1½ inches (3.8 cm.) between the internal femoral condyles when the heels were together. Definite anterior and outward bowing of the left lower leg was visible, and this leg was considerably thicker. At the point of greatest thickening, the left leg measured 16 inches (40 cm.), while a corresponding point on the right leg showed 15 inches (37.5 cm.) circumference. The ankles measured 9 and 9¼ inches (22.8 and 23.4 cm.), respectively (Figs. 1 and 2).

Palpation of the upper left leg revealed no tenderness to deep pressure. The skin was dry but gave no evidence of an inflammatory condition. There was no delayed tenderness. The edge of the bone did not feel nodular but was distinctly massive and thick.

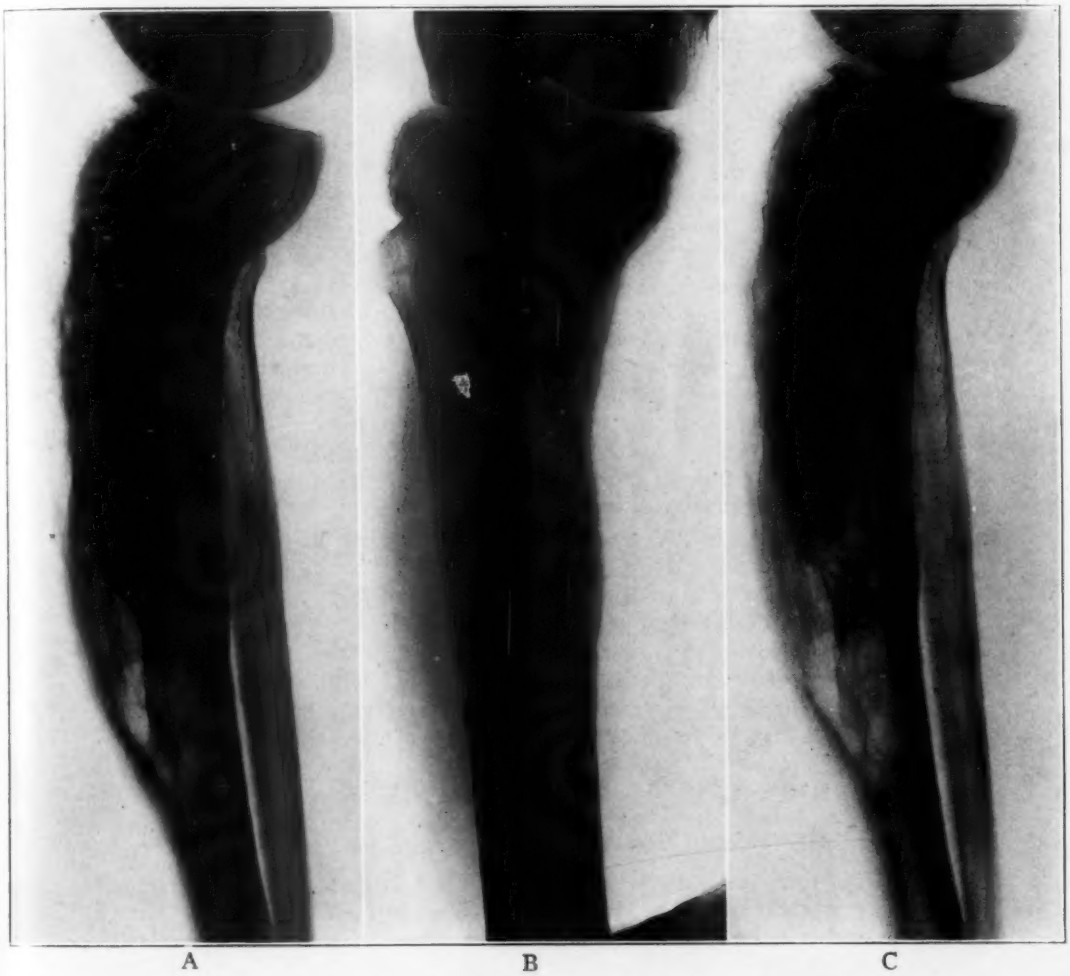
General examination: No evidence of senility could be found anywhere. The hair was not gray; there was no arcus senilis and no arteriosclerosis; the heart action was regular and strong; the blood pressure was 120 systolic, 65 diastolic, and the lungs were clear.

Laboratory Examination.—The Wassermann reaction was negative (two tests). Urine, stool and blood counts were all normal.

Roentgen-Ray Examination.—Roentgenograms were taken of the skull (anteroposterior and lateral), right and left arms, including the hands, thorax, spine, pelvis, femora and right and left legs and feet. In none of these plates, with the single exception of those of the left lower leg, was there

anything abnormal. These showed an expansion of the cortex of the upper left tibia with a peculiar linear decalcification of the upper two thirds of the bone (Figs. 3, A and B).

Course.—As the patient would allow no operative interference, even for the purpose of diagnosis, the case was followed carefully over a period of three years. In June, 1921, one year after he was first seen, a second careful physical



A B C

Fig. 3 (Case 1).—*A*, left tibia, lateral view (June, 1921): expansion of cortex, anterior bowing and new bone formation; linear decalcification is well shown; *B*, left tibia, anteroposterior view (June, 1921); *C*, left tibia, three years later (May, 1923).

examination was made, and the entire series of roentgenograms repeated. This was again carried out in July, 1922.

In May, 1923, he was carefully examined once more. Except for a slight increase in the process in the left tibia, revealed by roentgen ray (Fig. 3, C),

there had been no change whatever. The amount of medical attention which he received during this three year period had focused his attention on his legs to a marked degree. We feel that it is this fact rather than any real change which makes him feel that there is somewhat more discomfort now than before.

Summary.—The points deserving special emphasis in the foregoing report are (1) the general good health of the patient with the exception of the gallbladder condition and an infected finger; (2) the meagerness of any traumatic history; (3) the insidious onset, at the age of 44, of the lesion in the left tibia, characterized by thickening and bowing of the bone with increased bone production; (4) the presence of mild lumbago attacks with sciatica before the bony lesion was recognized; (5) the negative Wassermann reaction (repeated); (6) the negative roentgen rays of all other bones, and (7) the stationary condition of the lesion as shown by three years' careful observation.

Case 2 (Dr. Cyrus Sturgis' case).—*History*.—E. M., white, a man, aged 70, married, an American, salesman, who sought medical advice, Oct. 26, 1922, because of diarrhea, gave an essentially negative history. His father died at the age of 46, of an unknown cause. His mother died following childbirth. The patient had been married for "many years." His wife was living and well, but there have never been any children. He had the usual diseases of childhood, without complications. Six years previously, and again two years ago, he had attacks of bronchopneumonia, the latter lasting eleven weeks. When an infant, he fractured his left leg, which healed without trouble. When 30 years old, he had an attack of diarrhea similar to the one which brought him to seek medical aid at this time. Recently, he had had some difficulty in voiding and there had been nocturia (two or three times) each night.

For nine months, he had had a "used up" feeling at the close of each day's work, and for four months a diarrhea with an average of four loose movements a day. He had lost weight as a result of restricted diet and had worried a good deal, fearing a loss of his position.

It was noticed during the routine physical examination that there was a slight bowing of the right tibia without roughness or tenderness. When the patient was questioned regarding his knowledge of this, the following facts were elicited: He had no idea when the condition developed, but stated that he had realized for six months that it was present. For a month, the tibia had seemed somewhat thicker than previously. There had never been any pain connected with the condition, and only occasionally slight tenderness in this region.

Physical Examination.—The general physical examination revealed nothing of importance except for a moderately enlarged soft prostate and one small hemorrhoid. Proctoscopic examination and a barium sulphate enema both gave negative results.

Careful examination of the skeletal condition revealed nothing suggestive of the changes usually found in Paget's disease of bone. The posture was erect, and the arms were of normal size and length. The head, thorax, pelvis and left leg showed normal findings (exact measurements of the bony system were not made). The right leg showed a definite bowing of the tibia at its upper end, without roughness to palpation, or tenderness to pressure. There was no delayed tenderness.

The patient presented no more of the evidence of age than could be expected in a man of 70 years. He had the appearance of a person considerably younger.

The hair was gray; there was no arcus senilis, and the radial vessels were soft, but could be rolled under the finger. The blood pressure was 130 systolic, 70 diastolic, and the heart action was regular and good.

Laboratory Examination.—The Wassermann reaction was negative. Urine, stool, sputum and blood counts were all normal.

Fig. 4 (Case 2).—Lower extremity: typical lesion in upper right tibia.

Roentgen-Ray Examinations.—Films of the skull, pelvis and extremities revealed no variation from the normal with the single exception of the right tibia. Here there was definite anterior bowing with rarefaction and new bone production laid down in striations parallel to the shaft. Involvement included the head of the tibia (Fig. 4).

Course.—A diagnosis of ileocolitis without ulceration was made in addition to the incidental findings of prostatic hypertrophy and osteitis deformans (right

tibia). The patient was put on a suitable diet and medication, and the case was followed carefully in the subsequent months, showing improvement. There was a recurrence of his respiratory trouble in the form of bronchopneumonia about a month after he was first seen.

Four months previously, he bumped the right shin with a pan he was carrying and for a time thereafter had considerable soreness over the knee and upper leg. The roentgen rays revealed no change in the lesion already described. There has been no further change up to the present time.

Summary.—Special attention, then, may be called to the following facts in this history and examination. (1) The exceptional freedom from disease during a long life, with the two exceptions of one previous attack of diarrhea and two attacks of bronchopneumonia; (2) the absolute lack of any traumatic history connected with this bony lesion; (3) the insidious onset late in life of a lesion characterized by anterior outward bowing of the upper end of the right tibia, with rarefaction and new bone production; (4) the negative Wassermann reaction, and (5) the negative roentgen-ray findings elsewhere in the body.

Case 3 (Dr. E. C. Cutler's case.).—*History.*—October 6, 1922. W. B. B., aged 56, white, an American housewife, who sought advice because her leg had recently become bowed, gave a history essentially negative throughout. She had been married many years, and had one daughter living. Except for the usual minor complaints of childhood and adult life, her history has been uneventful. She had never injured her leg in any way.

One evening, the daughter remarked that she had never before realized that the patient was bow-legged. The patient then noted, for the first time, that her right leg was bowed outward and forward. She recalled that at times she had had "rheumatic twinges" in this extremity, but never any pain.

Physical Examination.—The patient was well developed and well cared for. Nothing abnormal was found except in the right lower leg. The shin on this side was definitely of the scabbard type. There was visible outward and forward bowing of the tibia without shortening. The edge of the bone seemed thickened to palpation, nontender and without increased heat or redness. There was no delayed tenderness. Flexion and extension were free and painless. There was no disability. There were no signs of early senility. The Wassermann reaction was negative.

Roentgen-Ray Examination.—There were no abnormalities other than a marked thickening of the anterior cortex of the right tibia, which was perfectly smooth and showed no rarefaction, consisting of laminations laid down parallel to the bone. The marrow cavity was narrowed (Fig. 5).

Course.—Since the foregoing observations were made, the patient has left this city, so that followup plates have been impossible. She writes (August, 1923) however, that her condition remains the same, symptomatically and physically. She favors the right leg when standing for any length of time, and thinks there may be slightly more bowing than before.

Summary.—A very well, rather young appearing woman of 56 years presented: (1) a good past history; (2) no history of trauma connected with the right leg; (3) a deformity appearing quietly late in life in the right lower leg, which gave a markedly bowed appearance to the latter, outward and forward, which by roentgen ray was seen to be constructive as well as destructive, and (4) a negative Wassermann reaction.

COMMENT

Three cases are reported, with a deforming bony lesion of the tibia, none of them appearing to have a traumatic origin, causing no disability and little if any inconvenience, existing unknown for some time before they were discovered, and in the first case showing no progress during three years of close observation.

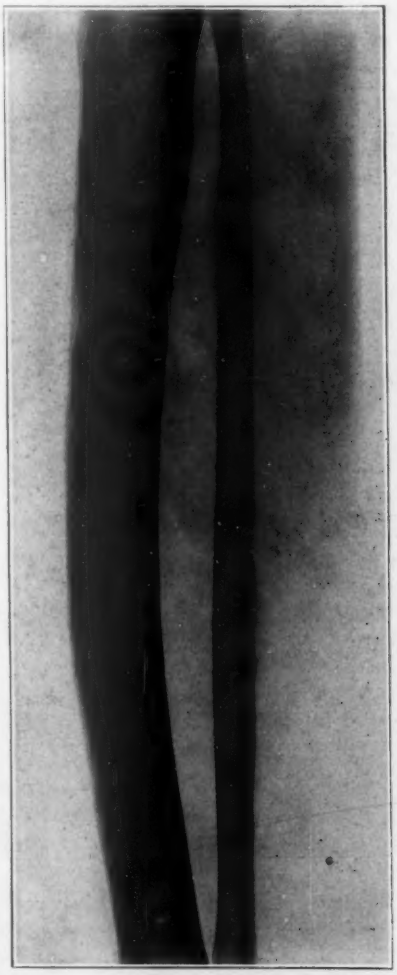


Fig. 5 (Case 3).—Lower extremity. The right tibia is markedly bowed and the cortex thickened.

No pathologic examination of tissue from these bones was possible in any of the cases, owing to the patients' objections. The diagnosis must rest, therefore, on (1) the characteristic history briefly summarized above; (2) the definite physical findings, and (3) the careful roentgenographic studies.

The histories are in each instance consistent with Paget's disease. This is true as well of the local physical findings. It is to the roentgen-ray studies that we must look for final confirmation. In an excellent paper,[5] Carman and Carrick have given a careful description of what is present roentgenographically in cases of osteitis deformans. To quote:

> The whole architecture of the bone is altered, the essential features being porosis and the formation of new bone with hyperostoses, one or the other process predominating in different parts. In later stages, the new bone tends

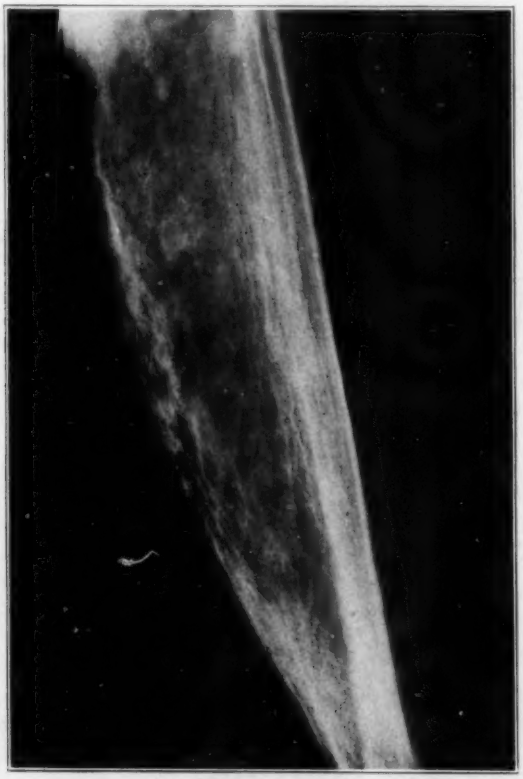


Fig. 6.—Tibia in osteitis deformans (after Carman and Carrick, Journal of Radiology, April, 1921, Fig. 3).

> to become sclerosed and takes on a dense white appearance with a much decreased permeability to the roentgen rays. The structure of the bone appears to be almost entirely removed and laid down afresh on a different plan and in a larger mold. The long bones lose their clear cut outline; they become curved, and the thickening appears to be greatest on the convex surface. In some places subperiosteal thickening is seen, while in others decalcification beneath the periosteum has progressed irregularly. The small cysts frequently mentioned in the literature were observed but once in our series.

For the sake of comparison, a reproduction of the roentgenogram (Fig. 6) of the tibia in one of their cases is included.[23] The roentgenograms in Cases 1 and 2 (Figs. 3 *A* and *C* and 4) correspond well with this picture. Figure 5 (Case 3) shows a somewhat more characteristic picture in that more of the entire length of the bone is affected by the process.

DIFFERENTIAL DIAGNOSIS

Of the various lesions which may be confused with the mono-osteitic form of Paget's disease, a few stand out prominently. Osteomalacia, osteoperiostitis, ostemyelitis, osteitis fibrosa cystica (Recklinghausen's disease of bone), malignancy and syphilis head the list.

To distinguish osteomalacia from Paget's disease should give little difficulty. It is essentially a loss of calcium which causes angulation in the bone, rather than a diffuse bending. Frequently, fracture results. The lesions occur in the pelvis and lumbar vertebrae, and sometimes in the entire skeleton. Very rarely do they occur in single bones. The clinical appearances and the roentgen-ray picture are distinctive and not to be confused with those presented in osteitis deformans, in which there is always a laying down of new bone coincident with the softening and bending of the old, and in which fractures are very uncommon.

Osteoperiostitis and osteomyelitis are both essentially inflammatory conditions showing local tenderness, swelling, redness, etc., often accompanied by a systemic reaction. The chronic forms reveal sequestrums by roentgen ray. The diffuse hyperostosis which appears about such lesions differs materially from the disease we are dealing with.

The dividing line between osteitis deformans and osteitis fibrosa cystica is more finely drawn. Many believe that the two cannot be separated histologically. The latter occurs earlier in life, and is much more prone to be the seat of pathologic fractures than is Paget's disease. Recklinghausen, who describes it, considers it to be a separate entity; basing this on the formation of separate cysts filled with gelatinous substance in the marrow, combined with the appearance of small tumors, reddish brown in color, with abundant giant cells of the myeloma type. The production of new bone from the periosteum does not keep pace with the absorption and destruction in the interior, the cortex of the bone being reduced to a thin weak shell. Fracture thus often becomes the factor which draws attention to its presence. The roentgen ray usually reveals a more general involvement of the part of the bone affected, rather than the one-sidedness typical of osteitis deformans.

23. Reproduced through the courtesy of Dr. Carman of Rochester, Minn.

Myles and Thompson [24] very aptly liken the appearance of the bone in osteitis fibrosa cystica to "an unevenly filled sausage." Trabeculation, a prominent feature in Paget's disease, is absent in Recklinghausen's.

Secondary malignant lesions, when the metastases are limited to one bone, may occasionally be mistaken for osteitis deformans. Le Wald particularly emphasizes this fact. In four of the cases which Carman and Carrick reported,[5] such a mistake was at first made because of the dense white chalky appearance of some of the lesions. The important difference in the osteoplastic types of secondary malignancy is the areas of extreme density and destruction which they alone present. Carmen and Carrick feel this mistake is most likely to be made when the lesions are in spine and pelvis.

The wide distribution of syphilis and the frequency of local bony lesions of this etiology make it always necessary to rule this out. History, Wassermann reaction and physical examination are of great help. Roentgenograms reveal irregularities on the surface of the bone, with a definite thickening of the cortex at the expense of the medullary canal and usually a periosteal reaction. Pain is more pronounced in syphilis than in osteitis deformans, and the incidence of syphilitic periostitis of the long bones is much greater in young people than in old.[25]

SUMMARY

Paget's disease of bone (osteitis deformans), an unmistakable disorder in its outspoken form, is nevertheless a rare disease. The so-called mono-osteitic type is still more uncommon. When, however, it appears, it presents in a single bone exactly the same clinical picture and roentgenographic findings which are present in the generalized form. While it seems possible adequately to differentiate this type from other single bone lesions, until more information is forthcoming we must content ourselves with the view that these cases are possibly nothing more than localized expressions of the better known more generalized disease.

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24. Myles, A., and Thompson, A.: Manual of Surgery, Ed. 6, London, Oxford Medical Publications **1**:478, 1921.

25. Weber, F. P.: A Note on Congenital Syphilitic Osteitis Deformans, Brit. J. Child. Dis. **5**:83, 1908.

THE SURGERY OF THE PITUITARY BODY

WITH ILLUSTRATIVE CASES *

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For this discussion of pituitary problems, I have selected from my records of the past three years a series of eighteen consecutive cases, representing what were regarded as primary intrasellar lesions, for the relief of which a transsphenoidal hypophysectomy was performed. In this series, there were no operative fatalities. Three patients have died in the interim, and of the remaining cases the results have been satisfactory in 75 per cent. I have not included in this discussion, but will reserve for a later paper, hypophysial duct tumors, tumors of the pouch of Rathke and tumors adjacent to the pituitary but not of pituitary origin, lesions which when recognized are best approached by the transfrontal operation.

The pituitary body offers an interesting theme for discussion from many angles, the more interesting perhaps because there are now and will be for years so many problems still undetermined, problems relating not only to the normal function of the gland, but also to its abnormal function and to the methods of relieving the symptoms resulting therefrom.

From the experimental point of view, there are still widely divergent views. Is the pituitary essential to life? Are not the syndromes commonly attributed to the pituitary body due to compression of nervous centers nearby in the infundibulum or tuber cinereum? Camus and Roussy,[1] from their recent experiments, would have us believe that the gland is not essential to life. Allen and Sweet drew the same conclusions from their experiments many years ago. They have dispossessed the gland of many functions hitherto attributed to it, reverting to the opinion of Erdheim, of a decade ago. In the clinical field, there are many things still unexplained. Is gigantism and acromegaly one and the same disease? In the Fröhlich syndrome, how much is due to the hypophysis alone and how much to a pluriglandular disturbance? Why, in apparently parallel lesions, should one present symptoms of acromegaly and the other not? These widely variant manifestations are still to be explained. How much at sea we are still

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* Read at a meeting of the Philadelphia Neurological Society, Jan. 26, 1923.

1. Camus and Roussy: Rev. neurol., June, 1922.

in the treatment of pituitary disorders with glandular preparations. There is but one striking and constant effect, and this only transitory; namely, the effect of posterior lobe extract on diabetes insipidus.

The problems with which the surgeon is confronted are not so complicated as those of the physiologist and clinician. The surgery of the pituitary body is still in the developmental stage. What may be a prevailing practice today may change tomorrow. Already the pendulum has swung back and forth in favor of one or the other method of attack. The surgeon is now studying methods of differentiation between primary intrasellar and extrasellar lesions. Later, he may be able to determine to what extent the lesion has outgrown the confines of the sella. On this differentiation and these distinctions must be made his choice as to his approach to the lesion, whether by a method essentially extracranial or one which is essentially intracranial. He knows that it is safer now to approach the primary intrasellar lesion via the sphenoid sinus. In the future, he may be able to deal equally safely and more effectively by approaching the lesion from above.

Although in the majority, if not in all instances, the patient is referred to the neurosurgical clinic for restoration of vision, it may be of interest to review the clinical findings from the standpoint of glandular disturbance, pressure phenomena, visual disturbance and roentgen-ray findings. The duration of the lesion is, of course, a matter of speculation in many cases, but so far as could be determined from the appearance of the first suggestive symptom, the period of the disease varied from one to twenty-nine years. For example, there were three patients in whom the menses had ceased at the ages of 29, 26 and 26, respectively, who did not appear for treatment until they were 39, 45 and 55 years old. The apparently long duration of the lesion in the last of these three cases aroused our interest. Ten, nineteen and twenty-nine years had elapsed between the first suggestive symptom and the date of operation. The following is an illustrative case:

CASE 18.—A. M., a woman, aged 55, referred to the neurosurgical clinic by Dr. William E. Monroe, had always been delicate as a child, and she "had had trouble" ever since puberty. The menses ceased at the age of 26. When 35, she was operated on for appendicitis, and the surgeons told her that the uterus and adnexa were infantile in type. She had run through the gamut of infectious diseases, diphtheria, scarlet fever, typhoid, influenza, rheumatic fever, tonsillitis and malaria. There were no glandular dyscrasias in the immediate family. Four years prior to her admission to the hospital, after a severe cold, she noted pain in the head and eyes. Various remedies were resorted to but failed. Her headache continued; she had attacks of nausea but no vomiting, and vision had gradually failed. Three months before admission, a roentgen ray was taken, which revealed the pituitary lesion.

Four patients (Cases 7, 16, 9 and 11) presented pronounced stigmas of the acromegalic type, but in the majority the glandular dis-

turbances were those of the Fröhlich syndrome. Accession in fat was observed in six cases, but in none to a marked degree; in two, there was scant pubic and axillary hair; in five, general apathy and indifference was marked (Cases 2, 16, 3, 4 and 7). In one of these (Case 4), there had been a striking change in the patient's temperament. Prior to his illness, he had been of rather buoyant spirits, active and successful in business, but he became quiet and listless, and drowsy at times, and exhibited the most supreme indifference to the gravity of the situation, not only at the time of his hospitalization, but afterward. Somnolence was noted conspicuously in three instances (Cases 8, 16 and 18).

As to the organs of reproduction, there was sexual apathy in two out of seven of the male subjects and amenorrhea in six of the eleven females, menstruation having ceased in four of these at the age of 19, 26, 29 and 26, respectively.

As might have been expected, the basal metabolism was subnormal, the lowest minus 51 and the highest minus 19. A subnormal metabolic rate should be a uniform finding and might be of value in the recognition of pituitary disorders in the early stages. There may be exceptions to this rule in instances of polyglandular disorders. For example, in one of my cases the metabolic rate was within normal limits, although the patient had a pituitary adenoma and hyperthyroidism. It seemed that one disease had offset the other. Cushing found two exceptions in his series, in both of which there were associated symptoms of hyperthyroidism and, following a sella decompression, the thyroid symptoms were favorably influenced and the metabolic rate returned to normal.

There was no evidence of polyglandular disturbance other than those of ovaries and testes already mentioned.

INTRACRANIAL PRESSURE

We are not accustomed to associate signs of increased intracranial pressure, such as general headache and vomiting, with pituitary lesions, and when these are in evidence, one may suspect that the lesion, extending beyond the confines of the sella turcica, has by pressure on the third ventricle, precipitated an obstructive hydrocephalus, with all which that implies. In this respect, the clinical expression would not differ essentially from the pressure effects of a purely intracranial neoplasm. In only one of our series (Case 3) was there recorded a marked increase in pressure as measured by the spinal manometer.

Headache of pituitary origin is the result of tension within the glandular capsule, beneath the diaphragm. It differs in a number of respects from that of the brain tumor; it is not usually so intense, it is not so often associated with nausea and vomiting and it is referred

usually to the frontal or temporal regions and not to the occipital. I have only in exceptional instances, to one of which I will refer later, found it a symptom sufficiently urgent to be a factor in the decision for or against operation. In one half of the series, there was no headache; in one quarter, it was moderate, and in the remaining severe. Several patients complained of sharp shooting pains in the head and eyes which might be attributed to the pressure on neighboring branches of the gasserian ganglion.

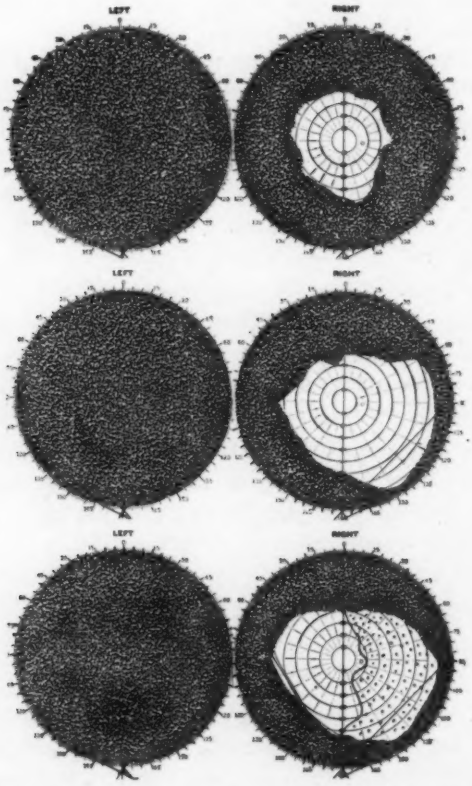

Fig. 1 (Case 8).—Right, above: right eye before operation; center: immediately after operation; below, later period with beginning recurrence. A still later observation shows the field full and normal. The left eye in each instance had only light perception.

The sudden cessation of headache is an occasional and significant symptom implying, as I believe, a spontaneous decompression by erosion of the sella floor or perhaps a rupture of the diaphragm. Erosion or perforation of the sella floor is not infrequently observed in the course of a transsphenoidal operation. In one of my cases, the

patient's headache had ceased spontaneously ten years before she was operated on.

CASE 8.—A. L., a man, aged 33, referred to the neurosurgical clinic by Drs. David Riesman and E. A. Sweeney, and who had been discharged from the Army in December, 1918, without any physical disability, presented the most distressing headache of the series. In the spring of 1919, he began to have pain in the head, especially in the left temporofrontal region, occasionally associated with vomiting. For the three months prior to his admission, the headache increased in frequency and severity until he became totally incapacitated and was confined to bed. The roentgen ray and ocular findings revealed a pituitary lesion. At the operation, a pituitary cyst was evacuated, with complete relief of the headache and, up to the present time, without recurrence. With the disappearance of the headache, there has been a decided and maintained improvement in vision, which is now 20/20 without the aid of glasses (Fig. 1).

Attempts at relief of headache by the conventional subtemporal decompressions have been so disappointing that efforts in this direction have been abandoned. My first and only experience a number of years ago failed absolutely. Since that time, reports from other clinics have convinced me of the futility of this operation.

In but one of the series were there symptoms which might have been interpreted as indicative of an extracranial extension of the lesion. The reflexes in one instance were recorded as diminished, but in all other respects, save one, the symptoms were referable alone to disturbances of pituitary function and pressure on the superimposed optic tracts or chiasm. In the single exception, the roentgen ray revealed the shadow of a calcified tumor extending beyond the limits of the sella turcica, and in this case we found a paresis of the external and superior recti muscles with diplopia, and an area of hypesthesia in the distribution of the left maxillary division.

The relation of pituitary lesions to acquired syphilis has been well covered in a contribution from de Schweinitz,[2] who refers to one of his patients (Case 4, G. B., aged 46) on whom I subsequently operated, the only case in this series in which there was a positive Wassermann reaction; the only case in fact in which there was any question as to the relationship of the pituitary lesion to syphilis. After an intensive course of treatment with arsphenamin under the direction of de Schweinitz, there was a decided improvement in vision and enlargement of the fields. Later, there was a recurrence of pressure disturbances, and a transsphenoidal operation was performed, with partial evacuation of the sella contents. In his classification, de Schweinitz regarded this case as one of hypophysial disease in a case of acquired syphilis, in which the pituitary body lesions were definitely, or in all probability, syphilitic.

2. De Schweinitz, G. E.: Arch. Ophth. **50**:203 (May) 1921.

SELLAR DEFORMATIONS

Conclusive evidence in the diagnosis of pituitary lesions usually is revealed in the roentgenogram. The dimensions of a normal sella, according to Pancoast, should not exceed 10 by 12 mm. When exceeding these dimensions, the sella turcica may be said to be abnormal. In the majority of cases, by the time the patient seeks surgical relief the

Fig. 2 (Case 9).—Characteristic sella excavation (measurements: antero-posterior 24, vertical 20), with virtually complete obstruction of sphenoidal sinus.

dimensions have exceeded the normal so much that there is no doubt as to the diagnosis. The character of the sellar deformation is of significance to the surgeon from a number of points of view, chiefly as to whether there is a primary intrasellar or primary extrasellar lesion. On this distinction will depend the choice of operation. It has been my rule to operate by the transsphenoidal route always when the roentgen

ray reveals the characteristic excavation of the sella, and to this rule in our series I made but one exception (Case 5).

To what degree the sphenoid sinus is encroached on by the sellar excavation is of some importance, partly as indicating the size of the lesion and partly as a measure by which one may forecast the improvement that may follow a sellar decompression (Figs. 2 and 3). In addition to the dimensions of the sella turcica and the encroachment on

Fig. 3 (Case 17).—Characteristic sellar excavation (measurements: antero-posterior, 24, vertical 16), with but little encroachment on the sphenoidal sinus.

the sphenoid sinus, the roentgenologic report should include a statement as to whether there is erosion of the dorsum sellae and posterior clinoid processes, as indicating a lesion of long duration and in all probability with an intracranial extension. Sometimes, as in those undergoing calcification, the nature and size of the lesion may be revealed in the roentgen-ray shadow, as in one of our series in which the outlines of the lesion were clearly defined (Fig. 4).

It was not difficult in most of our roentgenograms to differentiate between a primary intrasellar and extrasellar lesion. In most instances, the measurements of the sella turcica far exceeded the normal. Whereas the maximum anteroposterior dimension for the normal is 12 mm., in most of our cases the anteroposterior measurement was from 20 to 27 mm. The depth of the sella is the most important dimension as indicating a primary intrasellar growth. Here, too, in most of our

Fig. 4 (Case 18).—Calcified area above sella indicated by roentgen ray as irregular mass.

cases the measurement far exceeded the normal. The posterior clinoid processes were atrophied in more than two thirds of the series, indicating in part the extension of the growth beyond the sellar limits and in part a lesion of long standing. In about half, there was 50 per cent. or more encroachment on the sphenoidal sinus, as shown in the accompanying table.

OCULAR PHENOMENA

The characteristic alterations in the visual fields of primary intrasellar lesions are well known. In the vast majority of cases, and this applies to my own series, there is a bitemporal hemianopsia at the time the patients come to the surgeon for relief. One is impressed in reviewing the fields of any number of cases, and more particularly in testing visual acuity, with the difference between the two eyes. In practically all cases, one finds that the vision began to fail first in one eye. In my own series, there was no predominance of one or the other side. In one half, vision failed first in the right, and in the other half, in the left eye; and in testing visual acuity before operation one finds

Summary of Essential Data in Series of Eighteen Cases

Case	Age	Sex*	Type†	Visual Fields‡	Headache§	Nausea or Vomiting	Roentgen Ray Antero-posterior	Depth	Atrophy of Clinoids#	Sphenoid Encroachment per Cent.	Treatment¶	Operative Result‖
1	48	♂	A	Lth Rth	+	0	..	..	..	...	Op.	R
2	45	♀	F	Lth R—	0	1	..	..	..	...	Op.	R
3	44	♂	F	Lth R—	+	0	..	..	2	80	Op.	R
4	45	♂	F	Lth Rth	0	0	20	14	2	50	Op.	R
5	45	♀	..	Lth Rth	0	0	..	..	..	...	Op.	R
6	27	♂	..	Lth Rth	+	0	20	14	2	100	Op.	R
7	50	♀	A	Lth Rth	1	1	22	16	1	50	Op.	R
8	33	♂	F	L— Rth	+	+	20	16	0	80	Op.	R
9	21	♀	A	L— R—	+	0	24	20	0	80	Op.	R
10	48	♀	..	L— R—	0	0	13	12	2	50	Op.	R
11	49	♂	A	Lth Rth	+	0	17	13	1	0	Op.	R
12	23	♂	F	L ? Rd	+	0	..	..	..	...	Op.	R
13	19	♀	..	L— Rd	+	1	10	7½	0	0	R.	No op.
14	31	♀	..	Lth Rth	+	1	15	10	2	0	Op.	R
15	48	♀	F	Lth Rth	0	0	27	20	..	...	Op.	R
16	39	♀	A	Lth Rth	0	0	27	14	1	50	Op.	R
17	38	♀	F	Ld Rd	0	0	24	16	0	0	Op.	R
18	56	♀	F	Ld R—	+	1	12	12	0	0	Op.	R

* In this column, ♀ indicates female; ♂, male.
† F, Frölich; A, acromegalic.
‡ L, left; R, right; —, loss; th, temporal hemianopsia; d, defect.
§ +, present; 0, absent; 1, mild.
# 2, complete; 1, partial.
¶ Op., transsphenoidal hypophysectomy; R, radium therapy.
‖ R, recovery.

in a considerable number, between 40 and 50 per cent., that the patient is practically blind in one or the other eye. There are various reasons for this unfortunate delay between the onset of the visual disturbance and the time of operation. In some cases, it is the result of errors in diagnosis, in others of the patient's indifference. Often not until the sight is virtually lost in one eye and begins to fail in the other does the patient become concerned. The following is a case in point:

CASE 7.—M. V. A., woman, aged 50, referred to the neurosurgical clinic by Dr. G. E. de Schweinitz, nine years before had begun to complain of poor eyesight. She was examined and given glasses, which she wore for three years. Then other lenses were prescribed, and six months later, still others. At this

time, she noticed that every object seen with the right eye appeared to have a black vertical streak in the center. To the right of this, there was, she says, a thin brownish haze. This haze moved gradually to the left until, three years before her admission, the vision of this eye was totally lost. About the same time, that is, six years after the onset, and three years before her admission, she observed her vision beginning to fail in the left field of the left eye. Gradually, the sight of the left eye failed until, on admission to the hospital, she could see only the newspaper headlines. She had occasional attacks of nausea, but no vomiting.

Physical examination revealed that the brows were prominent and the physiognomy thick and heavy. The nose was wide and flat, but there were no other pituitary stigmas. The blood pressure was systolic, 128; diastolic, 80; the blood sugar before the ingestion of 136 gm. of glucose was 0.08 per cent., and at the first, second, and third hour afterward, 0.11, 0.136 and 0.134, respectively. The roentgen ray revealed marked encroachment on the sphenoid sinus, and the clinoid processes were totally atrophied.

There was no vision in the right eye; vision in the left was 2/60. There was a temporal hemianopsia and bilateral optic atrophy.

At the operation, after the sphenoid sinus was opened, the lesion presented, having decompressed itself spontaneously through the sellar floor. In this case, the tumor was not removed, as it had been planned after a simple decompression to rely on the effect of roentgen rays and radium. Three courses of radium and roentgen rays were given, but six months afterward, when the last examination was made, there was no sign of improvement.

In the eighteen cases of the series, an average of four years intervened between the first sign of defective vision and the admission of the patient to the hospital. The shortest period was four months (Case 4) and the longest nine years (Case 7).

The ophthalmoscopic examination records optic atrophy more or less advanced in both disks in ten out of sixteen cases. In one instance, it was recorded as slight in one eye and in one moderate, and in three the disk of one eye appeared normal. In one instance, the pallor was confined to the temporal side. As might have been anticipated, in but one was there any edema of the disk, and in this case there was only a haziness of the lower margin of the right disk.

The difference in visual acuity between the two eyes so commonly observed must be attributed to irregularity or unevenness in the superior surface of the lesion. This explanation I have verified in specimens removed at necropsy, when small nodular projections are seen on the surface of the adenoma.

Of the perimetric tests, with but two exceptions there was a bitemporal hemianopsia; in a certain number of cases, the history recorded a quadrinopsia as the initial field defect. There were but two cases, one doubtful, with a nasal quadrinopsia. Two cases presented a hemianopsia only for red, and one of these persists with perfect vision (Fig 5).

TREATMENT

One must consider in the management of the pituitary lesion with advancing visual disturbance three possible controlling agencies: glandular feeding, radiation and operation. In the symposium on the pituitary body at the third international reunion of the Société de Neurologie held in Paris, June 2-3, 1922, Froment, in discussing the possibilities of glandular or opotherapy, leaves one with the impression that glandular feeding has a very limited scope; that while favorable

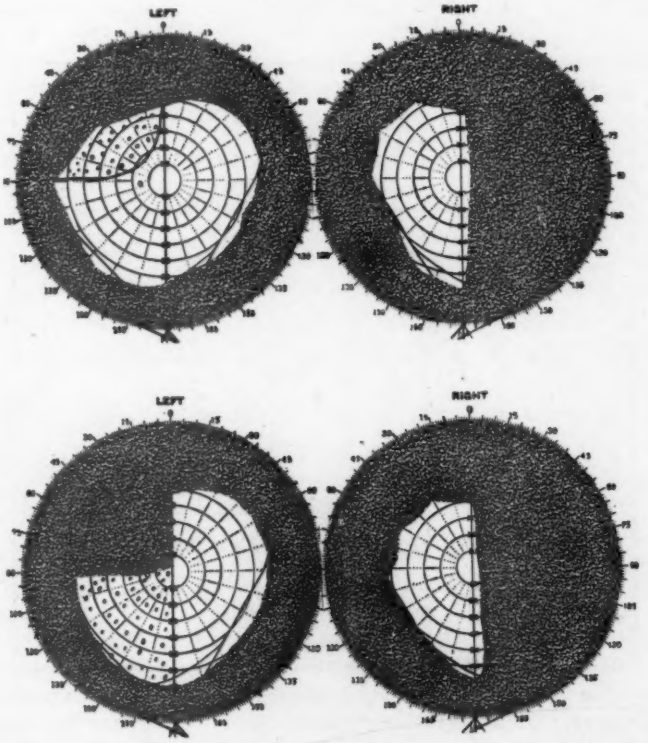

Fig. 5 (Case 6).—Above: left eye, quadrantic defect; right eye, temporal hemianopsia; below: two months later, left showing usual progress of field defect in pituitary lesions from quadrantic defect to hemianopsia following reverse direction of hands of clock; right, unchanged.

results have been obtained in one or the other manifestations of pituitary disorder, only in the exceptional case will any benefit be derived. Several years ago, I employed glandular extracts routinely after all operations, but not in a single instance did I observe any evidence of its effect on the lesion. Because of this experience and because in so many of my patients glandular therapy has failed before operation was considered, I have become very skeptical as to its effectiveness in

conserving vision. In one of my patients now under observation operation has been postponed pending the trial of glandular feeding and radiation.

CASE 18.—A. M., woman, aged 55, has a calcified tumor in and above the sella turcica and her vision while under observation has been stationary. Among the pituitary disturbances other than the visual defects were drowsiness, headache and a constant sense of chilliness. She lay in her bed sleeping most of the time with extra blankets and an electric heater nearby. Her basal metabolism was minus 51. In addition to radiation, she was given pituitary and thyroid extract three times a day. In the course of three months (Sept. 29, 1922, to Jan. 9, 1923), her metabolic rate has risen from minus 51

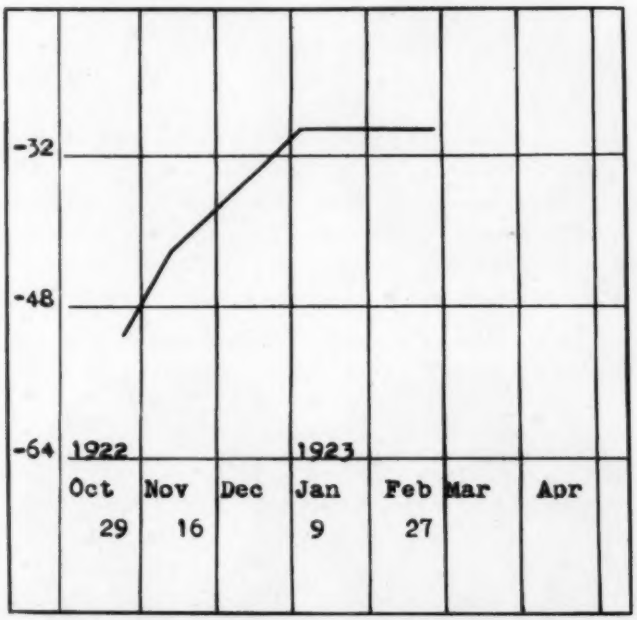

Fig. 6 (Case 18).—Chart showing increased rate of metabolism. The patient was receiving thyroid and pituitary extracts and irradiation.

to minus 29, she is relieved of the drowsiness and she no longer complains of feeling cold (Fig. 6). Whether these various signs of improvement should be attributed to radiation or glandular feeding is, of course, a matter of speculation, but as the improvement was noted a few days after the glandular extracts were given, one might reasonably attribute the improvement to those rather than to irradiation.

There is no question that in some cases pituitary lesions will respond favorably to irradiation. In this respect, the pituitary resembles the thyroid; which is not surprising, as there is a close analogy in the prevailing pathologic lesion of the two glands. Whether to advise immediate operation or irradiation to arrest the failing vision is a question

with which we are frequently confronted. Within the week, I was asked by de Schweinitz to see a patient who had already lost the sight of one eye, and the vision of the other had not been sustained by glandular extracts. With de Schweinitz's approval and with the understanding that the woman would report to him at stated intervals for examination, I decided to try the effects of irradiation. This, I believe, is a perfectly justifiable course under these restrictions, assuming that the treatment is to be undertaken by one experienced in the technic of irradiation as it should be applied to pituitary lesions.

Since Béclère's first observation in 1908, there is no doubt that irradiation, roentgen rays or radium, has exerted a favorable influence, not only on the visual but also on other evidences of pituitary dysfunction. Béclère himself records improvement in vision, headache, vomiting, convulsions, somnolence, apathy, metabolic disturbances and glycosuria and the arrest of skeletal changes.

Recognizing the potential value of irradiation, it has been our practice for the past three years routinely to refer all patients after operation to Dr. H. K. Pancoast for this treatment, and it is my belief that, by the combined method of dealing with pituitary tumors, operation and irradiation, we prolong the period of relief and prevent reçurrences. I will not attempt now to discuss the possible prophylactic effects of radiation after operation, as in many cases of this series sufficient time has not elapsed to justify a report as to end-results. Several more years must elapse before judgment can be passed. But I should like to refer here to one case, in which the field defect has disappeared almost entirely under irradiation.

CASE 13.—E. S., woman, aged 19, referred to the neurosurgical clinic by Dr. J. F. Dolphin, had been complaining of headaches since puberty, and during the past few months these headaches had been more frequent and more severe. Two months previously, she noticed spots floating in front of the right eye, and things looked blurred and dim. She was examined for glasses, but the headaches continued and vision became less acute. She was a well-developed young woman without any of the stigmas of the pituitary disorder. The spinal pressure was 8 mm. of mercury, the Wassermann reaction negative, and there was no evidence of organic disease.

The sella turcica was large, but had not exceeded what we consider the maximum normal limits. The visual fields showed a quadrinopsia in the right eye. The left eye was normal (Fig. 7).

The patient has received three courses of irradiation under the direction of Dr. Pancoast, and when last seen a few days ago, 13 months after the inauguration of treatment, the cut in the right field had almost disappeared, the headaches were relieved entirely and there was, according to her physician's statement, a marked improvement in distant vision of each eye.

As a matter of fact, there need be no controversy between the surgeon and the radiologist as to which of the two methods is superior, surgery or irradiation. Béclère does not state the case of surgery as

fairly as he should when he says that, even in experienced hands, operation is dangerous and very often fatal, and that the results are often very imperfect. The operative risks have been so reduced that to say they are often fatal misrepresents the situation as much as the statement that the results are frequently imperfect.

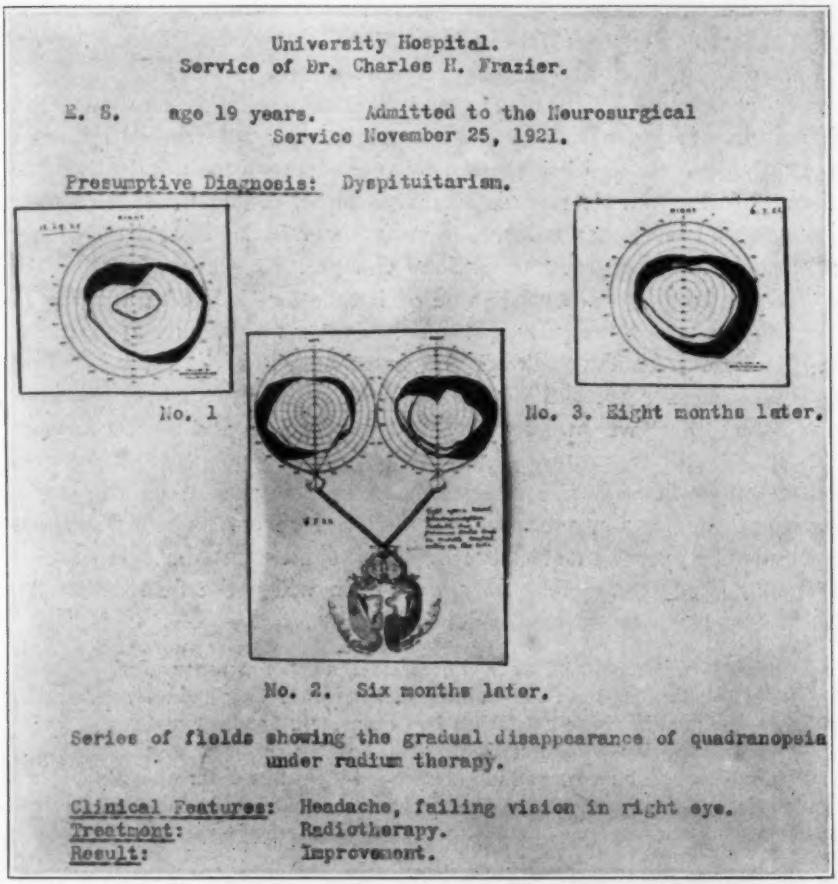
University Hospital.
Service of Dr. Charles H. Frazier.
E. S. age 19 years. Admitted to the Neurosurgical Service November 25, 1921.
Presumptive Diagnosis: Dyspituitarism.
No. 1
No. 2. Six months later.
No. 3. Eight months later.
Series of fields showing the gradual disappearance of quadranopsia under radium therapy.
Clinical Features: Headache, failing vision in right eye.
Treatment: Radiotherapy.
Result: Improvement.

Fig. 7 (Case 13).—Study to show effect of radiotherapy.

There is in many other respects, but particularly in the matter of treatment, an analogy between thyrotoxicosis and dyspituitarism. In both, at the onset of the disease, the management of the case may be entrusted to the internist; he failing, the effects of irradiation may then be tried, and irradiation failing, resort may be had to operation. This program is advised, conditionally, of course, on the understanding that the operation will not be delayed until optic atrophy is established or so advanced that restoration of vision is no longer possible. But what

may be accomplished by surgical means even in advanced cases is illustrated by the following case in which, after operation, the visual acuity improved from 1/20 to 20/25.

CASE 3.—C. S., a man, aged 44, referred to the neurosurgical clinic by Dr. W. A. Sawyer, about four years ago noticed a small triangular area of blindness in the right eye. This area became progressively larger, and in time the left eye became similarly affected. Deterioration of vision progressed until, at the time of admission, there was only light perception in the right eye and in the left eye the patient could only see large objects when nearby (Fig. 8). Occasionally, he had sharp shooting pains on either side of the head;

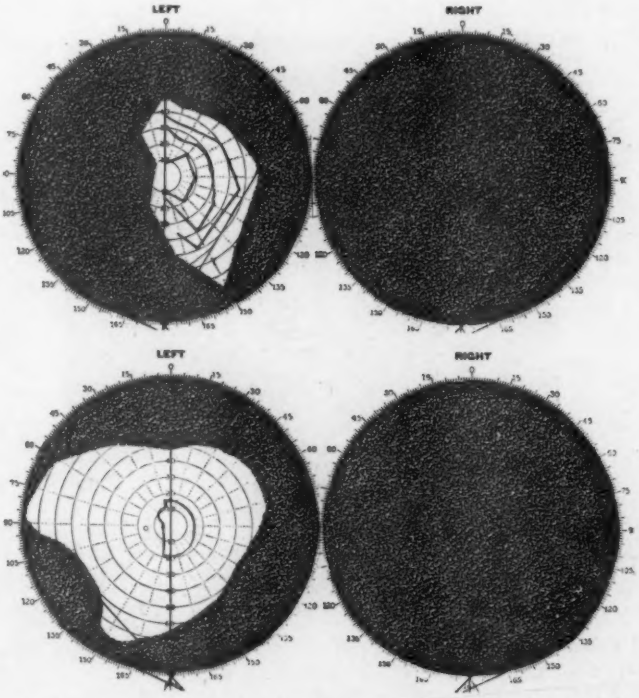

Fig. 8 (Case 3).—Above: visual fields before operation: right eye, no light perception; left eye, temporal hemianopsia. Below: visual fields recently taken: right eye, complete optic atrophy; left eye, form field normal. There is persistent hemianopsia for red.

but pain had not been a disturbing element, and there had been no nausea or vomiting. Lately, the patient has been exceedingly nervous. He is restless and wants to keep moving about. He has gained considerably in weight for the past six years, and during the past year he has become sexually impotent.

His family and social history were inconsequential.

Physical findings in brief were: glandular phenomena: obesity, sexual impotence; roentgenographic findings: almost complete obliteration of sphenoid sinus, posterior clinoid processes atrophied, deep sellar excavation; lumbar puncture: pressure, 30 mm. of mercury, cell count, 5 per cubic millimeter, Was-

sermann reaction negative, sugar and globulin positive; blood sugar, before ingestion of 100 gm. glucose, 0.12 per cent., one hour after, 0.17 per cent., two hours after, 0.14 per cent., three hours after, 0.13 per cent.; blood pressure: systolic, 87; diastolic, 160; ocular phenomena: vision, right eye, light perception, left eye 1/20; retinoscopy: right eye, advanced atrophy, left eye, moderate atrophy.

Transsphenoidal hypophysectomy was performed, Dec. 23, 1919, with operative recovery. Following the operation, the patient received a number of roentgen-ray treatments.

Jan. 13, 1923: Vision in the right eye was unchanged, there being light perception as before. In the left eye, the field was almost fully restored and vision had improved from 1/20 to 20/25 with glasses. The patient had been able to return to work and was no longer incapacitated.

Fig. 9 (Case 14).—Cosmetic result of operation; scar entirely concealed.

I shall not discuss at length the various methods of approach to the pituitary body and their respective merits, for I have included in this discussion only those cases in which operation was performed by the transsphenoidal route. Suffice it to say that I strongly advocate this as the operation of choice in all primary intrasellar lesions and, with the prospects of control by irradiation after operation, we have a plan of treatment that will prove effective in a considerable proportion of properly selected cases in which operation has not been too long delayed.

The cosmetic result, the element of safety and the assurance against recurrence should be the decisive factors (Fig. 9). As for safety, we have had no fatalities in this series, and this noteworthy elimination of risk is attributable only to our ability now to cope successfully with

technical difficulties which once confronted the surgeon in a field quite foreign to him. Nor will I discuss in detail the technic we employ. Suffice it to say that we find direct illumination, as furnished by our special speculums, vastly superior to any form of indirect illumination.

Primarily, of course, surgical intervention for pituitary lesions is undertaken for the relief of the effects of pressure, as it may affect vision or cause headaches. It is for this purpose, and not with the hope of affecting the consequences of disturbed glandular function, that the surgeon advises operation. Nevertheless, occasionally, the operation may be followed by noticeable improvement in one or the other manifestation of pituitary dysfunction. In one of my series, the coarseness of features so noticeable before the operation had almost entirely disappeared. As the patient says, her features are almost normal again.

Case 9.—A. B., a woman, aged 21, referred to the neurosurgical clinic by Dr. C. E. de M. Sajous, was in perfect health up to five years previously, when she noticed chilling and numbness of the fingers. At the same time, the fingers began to increase in size. She developed an abnormal appetite and her weight increased. Three years previously, vision became impaired and her features changed so that her friends did not recognize her. Medicines were prescribed and chiropractors employed, without results. A year later, menstruation ceased. Eight months previously she consulted Dr. Sajous, who prescribed irradiation and glandular feeding. She lost 9 pounds (4 kg.) under this treatment, but her vision continued to fail, her headaches became more intense and the hair was coarse and wiry.

The personal, family and social history were inconsequential (Fig. 10).

The clinical phenomena were: glandular disturbances: features, hands and feet of acromegalic type, hair coarse and abundant, sternum, second and third costal cartilages, prominent; pressure symptoms: headaches, neuralgia pains, bilateral optic atrophy; ocular phenomena: retinoscopy: right eye, disk oval, chalky white, left eye, primary optic atrophy; perimetry: left, light perception, right, upper and outer quadrant cut; vision: left, light perception, right, 6/6-2.

Transsphenoidal hypophysectomy was performed, June 18, 1921, with evacuation of sella contents and with operative recovery. Seventeen days after operation, there was some enlargement of the visual field in the left eye.

Jan. 23, 1923: Nineteen months after the operation, the patient reported by letter that her eye was improving from day to day, and her weight was stationary, menstruation had not been established, but her features seemed almost normal again.

In this case, there has been no sign of recurrence and the change in the features is worthy of note.

Case 16.—Mrs. C. S., aged 39, referred to the neurosurgical clinic by Dr. G. E. de Schweinitz, had a substantial loss of weight after operation. Only eleven months before admission the patient noticed failure in vision of the right eye. Later, there was accession in weight, somnolence and disturbance of vision, including a complete optic atrophy in the right eye, with a bitemporal hemianopsia. I have not received a report as to her visual fields, lately, but in a letter of recent date she writes that her vision is very much better and that she has lost 22 pounds (10 kg.) in weight since the operation was performed, about a year ago.

In addition to the loss of weight and the disappearance of the coarseness in features, the reestablishment of menstruation may be anticipated as in Case 14 of my series.

What may be anticipated after operation with regard to visual improvement immediately and ultimately is a matter of paramount interest. There are a number of factors which will affect the prognosis; notably, the character of the lesion and the degree of optic atrophy. The most favorable lesion and fortunately the most common is the adenoma. One might presume resumption of growth and recurrence

Fig. 10 (Case 9).—Acromegalic type.

of symptoms when the lesion was of a malignant character, and yet one of our most satisfactory results was obtained in a patient (Case 14) from whom an adenocarcinoma was removed (Figs. 11 and 12). While, hypothetically, the graver aspects of malignant lesions are recognized, it is generally accepted that the pituitary cyst is the most unfavorable of all lesions because of its tendency to refill. That this is not inevitable, however, is illustrated by the result of an operation (J. F. G., aged 7 years, referred to the neurosurgical clinic by Dr. G. E. de Schweinitz) performed five years ago, in which the improvement in vision, following the evacuation of a pituitary cyst, has been maintained.

How best to manage the pituitary cyst is one of the immediate surgical problems. Kanavel packed the cyst wall with a tampon saturated with a solution of iodin, but this seems a somewhat hazardous procedure. It may prove necessary in the event of recurrence to resort to a transfrontal operation and resect the cyst wall.

The prognosis will be effected, too, by the size of the lesion. When the tumor has extended beyond the confines of the sella turcica, the evacuation of its contents may *not* be followed by collapse of the

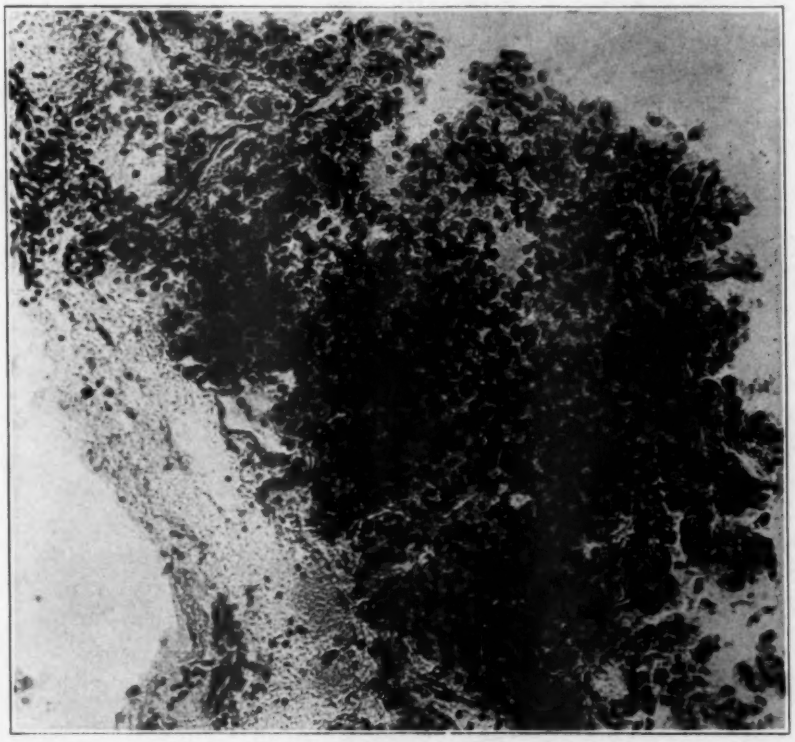

Fig. 11 (Case 14).—Adenocarcinoma of pituitary body (× 250).

capsule, so that the pressure on the optic chiasm persists. This I observed a number of years ago in one case in which later I secured the specimen at necropsy. But, generally speaking, the more complete the removal of the tumor, the better will be the results. A simple sellar decompression, even when followed by irradiation, is not sufficient. This was illustrated in one of my cases (Case 7), to which reference has already been made.

Finally, the degree of optic atrophy at the time of operation is a decisive factor in the extent to which vision may be restored.

I have reviewed the effect of the operation on vision in the series under discussion and, including those from which recent reports could be obtained, I find the results might be expressed as follows: In 35 per cent., there has been a striking improvement; in 35 per cent., moderate but sustained improvement, and in 27 per cent., the condition

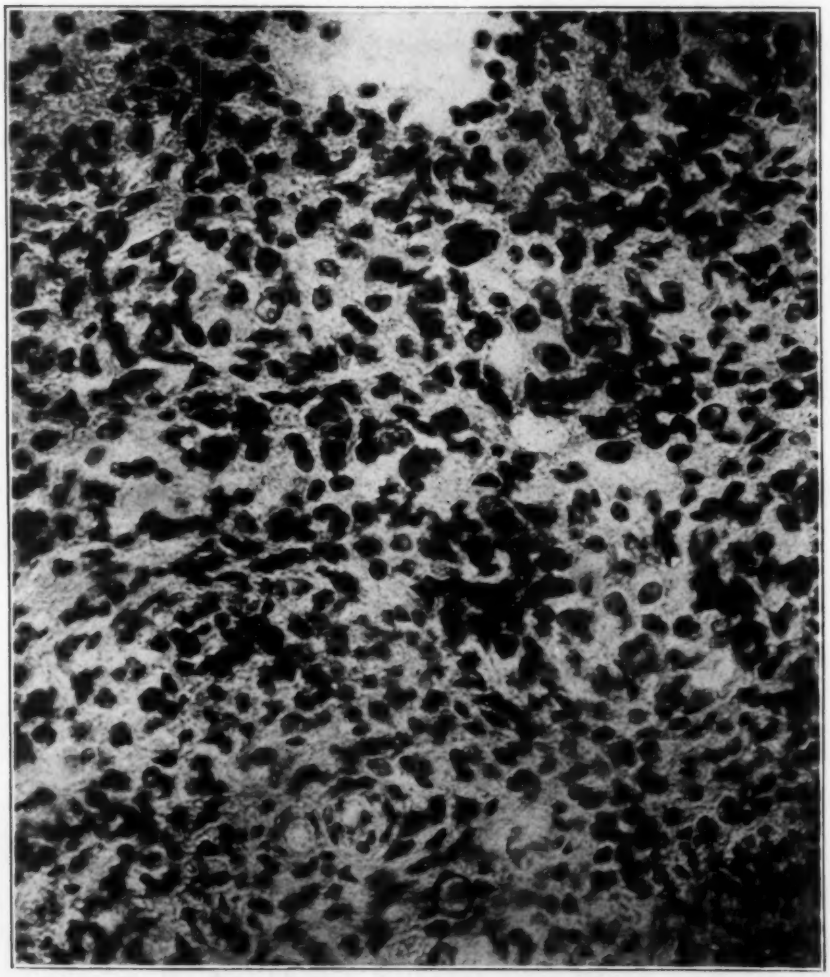

Fig. 12 (Case 14).—Adenocarcinoma of pituitary body (× 700).

is stationary or aggravated. The failure to secure results in the latter, I attribute in part to the advanced optic atrophy and in part to inadequate removal of tumor tissue. In a larger series of cases, Cushing [3] reports a marked improvement, with enlargement of the fields in 50

3. Cushing, Harvey: Rev. neurol. **29,** No. 6, June, 1922.

per cent. and a remarkable improvement with evident arrest of the process in 20 per cent. In other words, the transsphenoidal operation yields satisfactory results in 70 per cent.

These statistics, together with the low mortality, refute the remarks of Béclère, already quoted, as to the efficacy and risks of operative intervention. In the course of time, with proper selection of cases, with efforts to remove a larger part of the tumor and, more especially, with the avoidance of unnecessary delay, the percentage of improvements or recoveries of vision will be still higher.

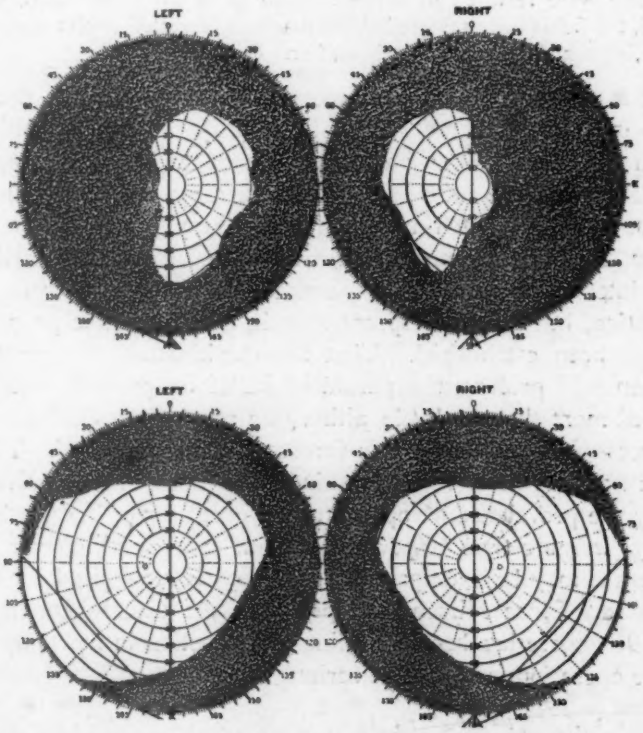

Fig. 13 (Case 14).—Visual fields before and immediately after operation.

That we may secure complete restoration in vision in both eyes in patients who have been operated on before optic atrophy is advanced should be borne in mind. Such was the case in a patient operated on two years ago (Fig. 13).

CASE 14.—L. B., woman, aged 31, referred to the neurosurgical clinic by Dr. William F. Mercer, was perfectly well until eleven months previously, when she developed an amenorrhea. Coincident with this, she complained of severe headaches at first over the right temple, later becoming general. These were associated with vomiting. For the past two months, she had had no headaches. Seven months previously, her vision began to fail, at first in the temporal field

of the left eye. This gradually grew worse, and the temporal field of the right eye became affected.

Clinical findings were: glandular phenomenon: amenorrhea; polyglandular phenomenon: adenoma of thyroid gland; roentgenographic findings: complete disappearance of posterior clinoid processes, preventing measurement of sella turcica, no encroachment on sphenoid sinus; ocular findings: vision: right, 20/20, left, 20/200; by perimetry: bitemporal hemianopsia; by retinoscopy: pallor of temporal side of both disks.

Transsphenoidal hypophysectomy was performed, with operative recovery. The pathologic diagnosis was adenocarcinoma.

Before discharge, the patient received one course of radium therapy and the visual fields were restored to normal. Two years after operation, the vision is normal, the fields fully restored. Menstruation, arrested twelve months before operation, returned four months thereafter.

In this cursory review, I have attempted to present the clinical features of interest in the study of pituitary disorder, dwelling especially on the visual disturbances, because of their outstanding importance. The relative merits of glandular therapy, irradiation and operation have been presented in an impartial way. The indications for operation, the successes and failures have been clearly set forth. That surgical intervention offers an assurance not only of the arrest of visual deterioration, but also of improvement in a considerable proportion of cases, has been established. That the combination of operation and irradiation will prolong the period of relief or prevent recurrence is considered more than probable, although a number of years must elapse in the cases presented before this forecast can be confirmed. That there has been needless delay in establishing a diagnosis is conclusively illustrated by the prevalence of optic atrophy eventuating in total blindness in one eye in more than 40 per cent. of our cases; and, conversely, that better results may be anticipated if the lesion is recognized sooner must be admitted. Since Hirsch first proposed the transsphenoidal operation in 1910, there has been a continuous reduction in mortality, so that today the operation is devoid of serious risk.

THE ETIOLOGY OF EXSTROPHY OF THE BLADDER

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Although much has been written on the etiology of exstrophy of the bladder and its allied malformations, the problems are far from settled, and comparatively little agreement exists. Through the kindness of Dr. Philip G. Young, a rare type of this malformation, which throws some additional light on the problem of the etiology, has been studied. It is the object of this paper not only to consider the probable embryonal development of this rare type, but also to discuss the etiology of the more common types, including simple epispadiades.

REPORT OF CASE

History.—The mother was a primipara, and labor was normal. Neither the family history nor the physical findings during pregnancy were suggestive, and the mother has since given birth to a perfectly normal child. Dr. Young stated that the time of the birth in question he noticed particularly the shortness of the umbilical cord; but unfortunately neither the placenta nor the cord was saved for further examination.

The baby was seen by me two days after birth, when careful notes and sketches were made. The antemortem findings are incomplete and even important structures, such as the openings of the ureters, were not identified. It was only after a postmortem examination had been made that these structures were recognized.

Physical Examination (July 21, 1921).—The infant was small, apparently weighing about 5 pounds (2,268 gm.). The skin was loose and wrinkled. The cry was shrill and feeble. No abnormality of the head, chest, neck or extremities was noted. The lower part of the body presented three striking malformations: a large red fungating tumor below the umbilicus; a marked spina bifida involving the lumbosacral region, and absence of an anus. No retroflexion of the trunk was noted.

The bladder had a trilobed appearance, which Wood-Jones[1] mentions as so characteristic of all types of exstrophy (Fig. 1). It extended from the umbilicus to the rudimentary penis, and its lateral diameter was considerably greater than its cephalocaudad diameter. The tumor protruded considerably, and presented a raw, bleeding, irregular surface.

On careful inspection, the protruding mass could be divided roughly into three parts: two more or less symmetrical lateral masses and an irregular central portion. The lateral masses were somewhat crescentic in outlines, of fairly firm consistency and a deep red. They were joined by a thin band

1. Wood-Jones, Frederick: Extroversion of the Bladder and Some Problems in Connection with It, J. Anat. & Physiol. **46**:193 (Jan.) 1912.

of tissue of similar consistency just below the umbilical cord, and thence they rapidly widened and ran, first, laterocephalad; thence, laterocaudad, and, finally, mesiocaudad, where they joined a central raised bar of tissue covered with a smooth red mucosa, which extended from the central portion to the base of the rudimentary penis.

The surface of the lateral masses appeared raw and was covered with urine, blood and particles of fibrin and mucus. The mucosa had a somewhat coarse villous appearance, quite unlike the smooth velvety appearance of the central portion. These masses protruded and consequently overrode the skin and rudimentary penis; but when retracted, they were separated from the skin by a shallow groove covered with smooth, glistening mucous membrane. The groove failed to meet caudally in the midline, being separated by the raised bar already mentioned (Fig. 2).

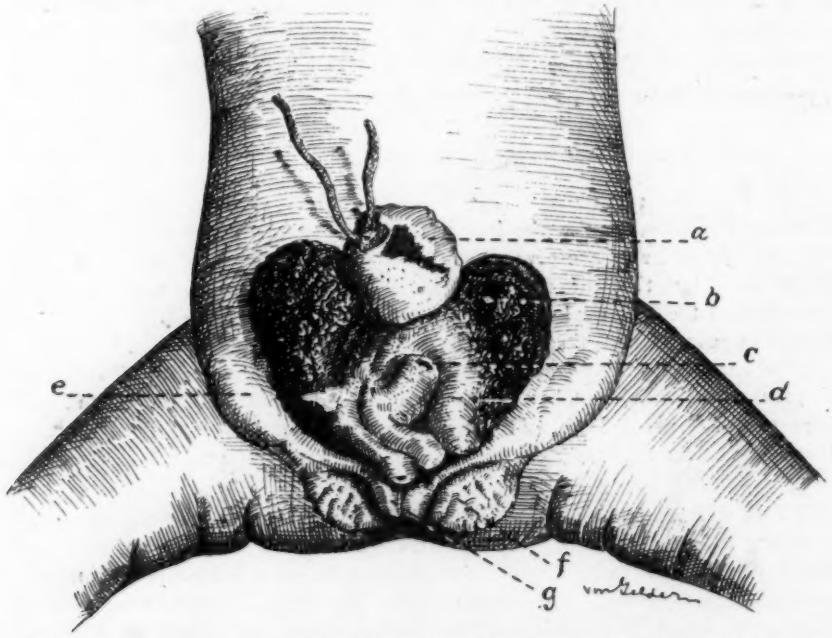

Fig. 1.—Appearance of exstrophic and adjacent parts two days after birth: *a*, stump of umbilical cord; *b*, lateral mass; *c*, opening of small intestine; *d*, central portion; *e*, swelling produced by undescended testes; *f*, left half of divided scrotum; *g*, rudimentary penis.

The central portion was markedly irregular in outline, displaying a number of nodular protrusions of varying size (Fig. 1). The mucosa was of smooth, velvety appearance, and was a deep red, but definitely lighter in shade than the lateral masses. In the center was a protrusion which was more prominent and presented a small opening through which gas and fecal contents escaped. During states of increased abdominal pressure, as in crying, this protrusion became more prominent and varied somewhat in position.

Although a number of efforts were made to locate the ureteral openings and differentiate other structures, these efforts were not successful, since the

protrusion was always under more or less tension and could be handled only with extreme care.

The rudimentary penis was a tonguelike process, tapering slightly, and measuring about 1 cm. in length. On the cephalic surface, which was covered by a pink mucosa, a shallow median groove extended along the entire length of the organ. This caudal surface was covered with skin essentially like the skin of the neighboring parts. The base was broad and firmly attached. On the proximal cephalic attachment, three ridges were noted: a median bar, extending from the midpoint of the penis to the central portion of the exstrophic parts, and two lateral ridges which extended from the junction of the lateral edge and the basal attachment, to the inguinal region, where they broadened out. These ridges were bounded by the shallow furrow on the cephalic side,

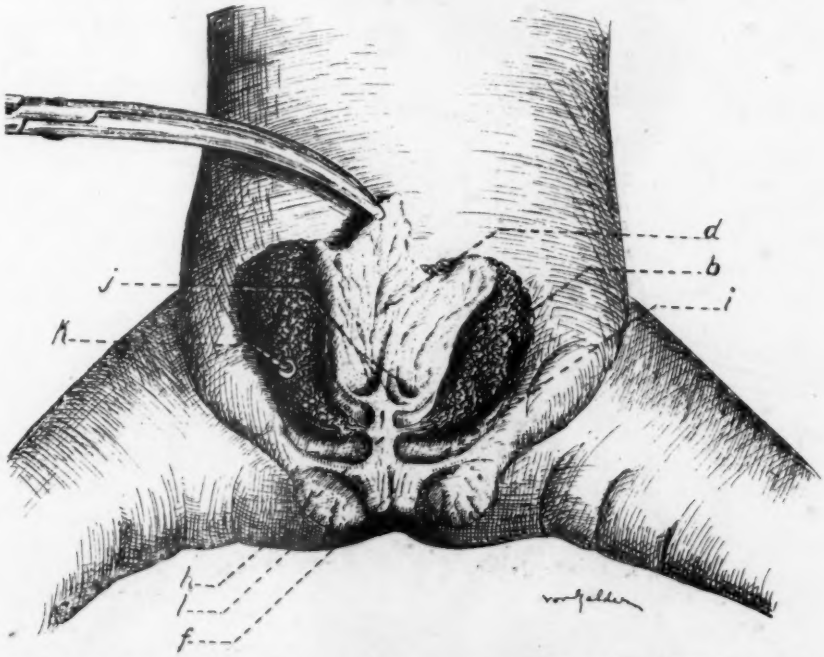

Fig. 2.—Appearance of the exstrophic parts shortly after death. The parts are flaccid owing to the loss of intra-abdominal pressure; *b*, lateral mass; *d*, central portion (retracted upward); *g*, rudimentary penis; *h*, central bar; *i*, furrow separating the lateral masses from the adjacent skin; *j*, slitlike openings, two lateral ones which communicate with the diverticula and a central one which communicates with a shallow culdesac; *k*, site of right opening of common duct for the vas deferens and ureter; *f*, right half of divided scrotum.

and by the scrotum on the caudal side. The rudimentary penis presented none of the structures found in the normal organ; namely, glans, meatus and prepuce.

The scrotum was divided into two parts, separated from one another by a distance of 1 cm. The skin of each scrotal tag had the characteristic puckered appearance of the normal scrotum. The intervening space was flat and smooth, and was continuous with the perineum.

The testes were felt, high in the inguinal canal. They presented the normal elasticity and could easily be forced through the internal ring into the abdominal cavity.

The baby took its nourishment well, but there was a steady loss in weight. The skin became more wrinkled and dry.

Death occurred, August 11.

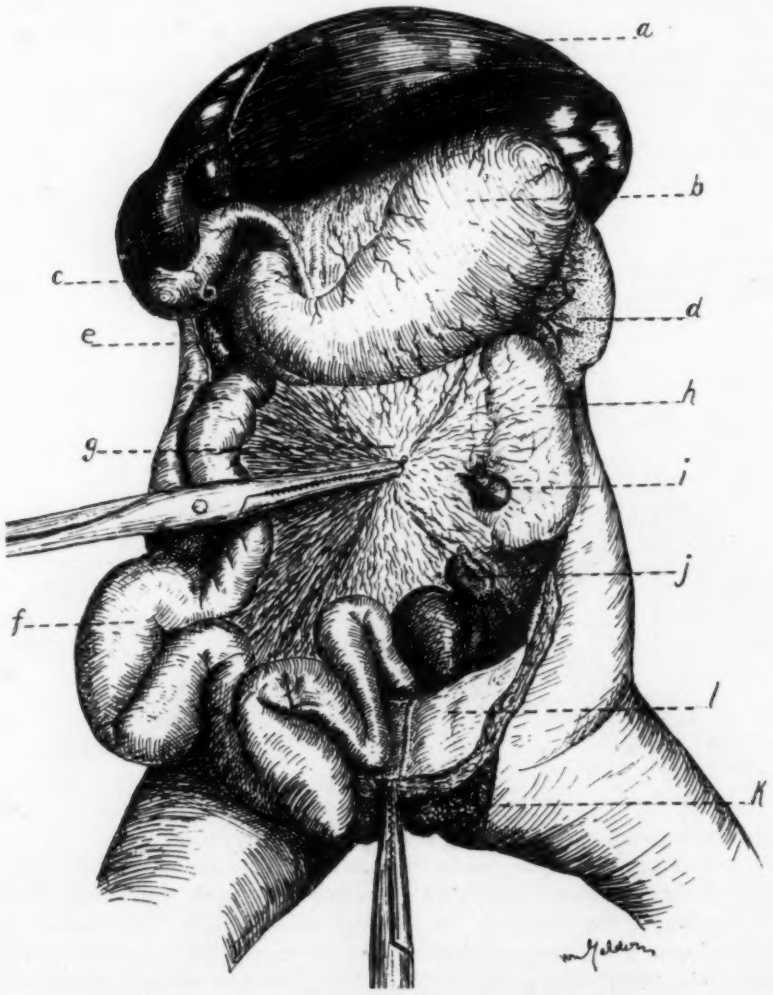

Fig. 3.—The anterior abdominal wall has been retracted downward to expose the abdominal viscera: *a*, liver; *b*, stomach; *c*, gallbladder; *d*, spleen; *e*, duodenum; *f*, small intestine; *g*, great omentum (by raising it near the center, its attachment to the mesentery of the small intestine and the parieties, is shown); *h*, left kidney; *i*, accessory spleen; *j*, left testes (this organ slipped back into the abdomen after death); *k*, left lateral mass; *l*, posterior view of anterior abdominal wall.

Postmortem Examination.—The body showed marked wasting of the tissues. The umbilical cord had fallen off. The umbilical region was smooth and presented none of the normal puckering and retraction of the skin. The eyes, ears, nose and throat presented no abnormality.

Description of the Exstrophic Parts: On retracting upward the central portion of the parts exposed by the exstrophic state, it was noted that the central bar became more prominent and continued as a median ridge into the retracted central portion, and that two lateral ridges were given off which continued along the inferior and lateral borders of the central portion. At this point of junction, three slitlike openings were noted: one central opening, which admitted a probe for only a few millimeters, and two lateral ones, which admitted a probe for about 4 cm. Just below the central ridge, there was a minute slitlike opening in the center of the median bar.

A transverse incision was made through the abdominal wall, above the umbilicus, and the edges were retracted.

There was marked deviation from the normal in appearance, size and position of the abdominal viscera. The liver was large, but otherwise showed no change in the number of lobes and fissures. The gallbladder and its ducts showed no abnormality. The stomach was markedly enlarged and distended, but it lay in a normal position, having completed its embryonal rotations. The gastrohepatic omentum showed no apparent deviation from the normal, lying transversely (Fig. 3).

The duodenum was short. Its third portion lay in the right hypochondriac region and did not extend across the vertebral column as is normally the case. Its embryonal mesentery had become fused to the posterior parietal wall as in the normal.

The small intestine was short and markedly dilated. It ran almost directly caudad along the right side of the abdomen, but its mesentery was attached along the midline of the posterior abdominal wall as in the embryo. The great omentum was attached along the greater curvature of the stomach and thence spread out as a thin red web, attaching itself to the small intestine at the mesenteric insertion, along the lateral parietes, and loosely covering the pelvic viscera (Fig. 3).

The small intestine emptied into the central portion of the exstrophic parts, as heretofore described. At this point, the gut was folded on itself, forming a typical intussusception. Apparently, on macroscopic examination, the large intestine was entirely absent. The pelvis was large and roomy, and the pubic bones were widely separated (Fig. 4). In the pelvis were found two large spindle shaped appendages. These lay on either side and were attached to the lower portion of the exstrophic parts, running dorsolaterad and thence dorsocephalad. A probe thrust through the lateral slitlike openings, below the central portion of the exstrophic parts, led into these structures. The middle slit, however, led into a short culdesac, as previously stated. These appendages contained a grayish white putty-like substance not unlike sebaceous secretion in appearance.

Lying deeply within the pelvis, between the two appendages, and closely associated with the posterior wall of the lower portion of the exstrophic parts, was a spherical structure measuring approximately 1 cm. in diameter. It was tense and elastic, and evidently contained fluid. It lay at the junction of the upper perineal muscles and the insertion of the genital tab (Fig. 21).

The kidneys lay on the iliac fossae, but showed no apparent variation. The ureters followed a normal course and each emptied into a lateral mass at

the junction of the middle and lower third. About 1.5 cm. above the termination, the vasa deferentia joined the ureters and emptied into them (Fig. 5).

The testes lay loosely in the abdominal cavity and could be thrust through the internal inguinal rings into the inguinal canals. They showed no apparent deviation from the normal.

The left umbilical artery was absent, but otherwise the vascular system showed no marked abnormality.

Histologic Examination.—Blocks cut from all the important structures were fixed in a 10 per cent. formaldehyd solution and mounted in celloidin, and

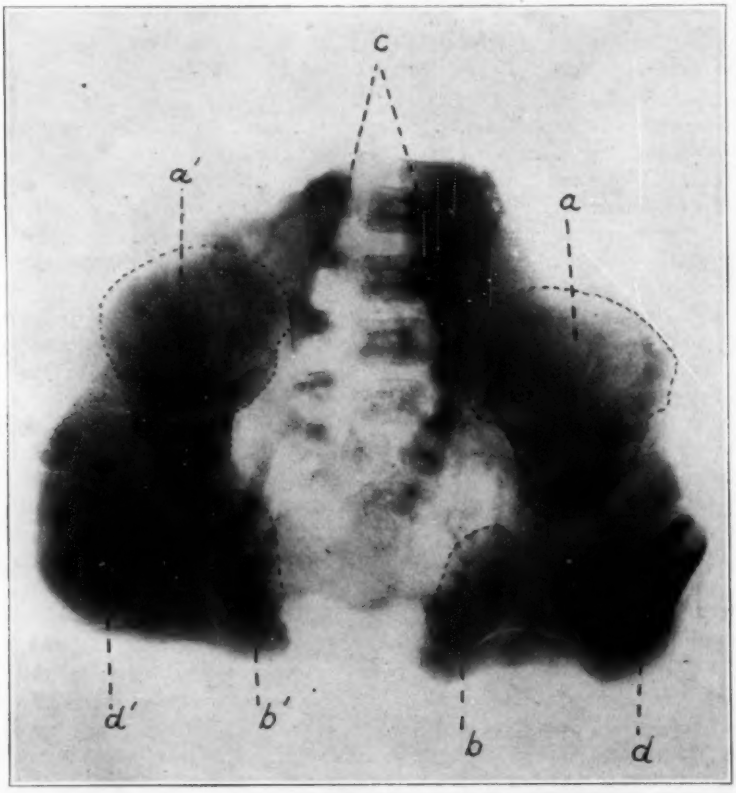

Fig. 4.—Roentgenogram of pelvis, showing the separation of the pubic bones and the separation of the laminae of the lumbar and sacral vertebrae: *a*, *a'*, ilia; *b*, *b'*, ends of pubic bones; *d*, *d'*, heads of femora; *c*, separation of the lumbar and sacral laminae.

the sections were stained with hematoxylin and eosin. These blocks are indicated in Figure 6. Further sections were made of the appendages of the exstrophic parts, the junction of the vas deferens and ureter, the junction of the small intestine and exstrophic parts, the spherical body lying in the pelvis, the genital tab and the testes.

Block 1: Tissue including the lower border of the umbilicus, the upper border of the exstrophic parts and the intervening tissue. The sections were

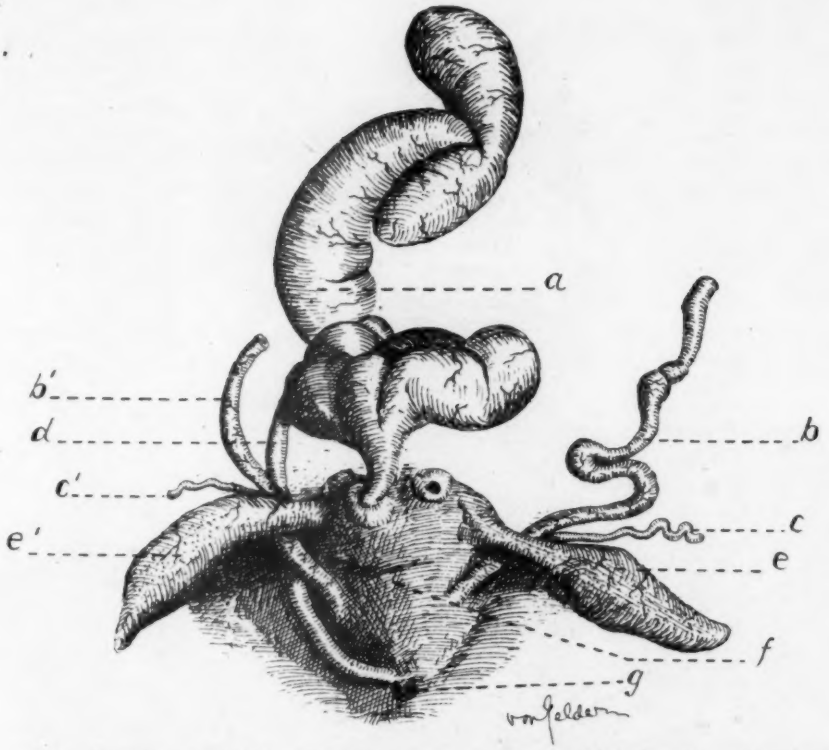

Fig. 5.—The exstrophic parts have been inverted and the anterior abdominal wall has been further retracted to expose its posterior surface: *a*, small intestine; *b*, *b'*, ureters; *c*, *c'*, vasa deferentia; *d*, right umbilical artery; *e*, *e'*, diverticula; *g*, umbilicus.

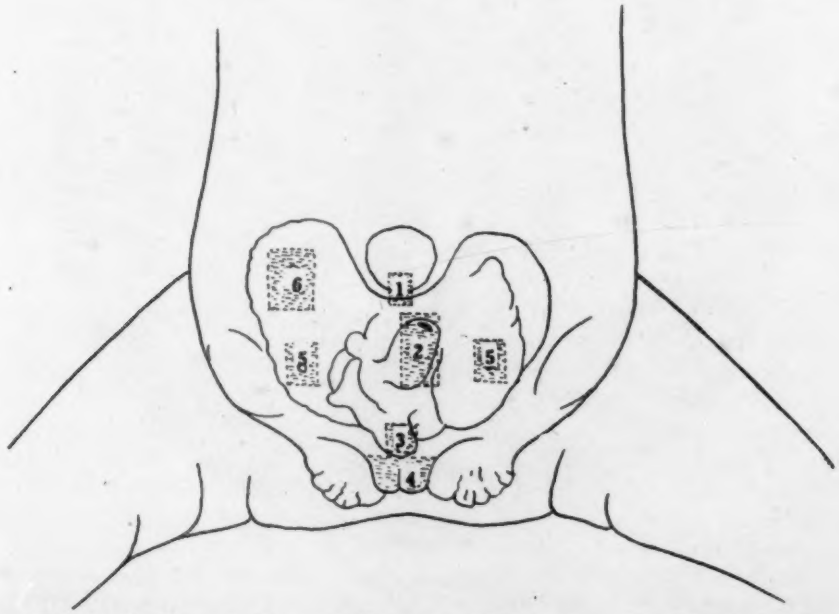

Fig. 6.—Outline of the exstrophic parts. The shaded areas indicate the parts from which sections were cut.

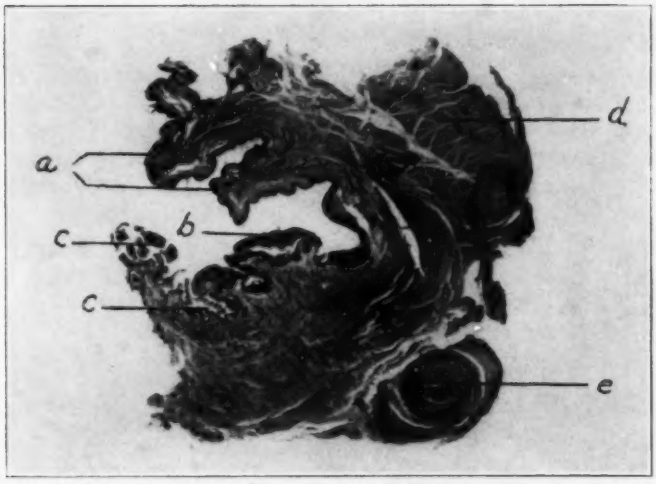

Fig. 7.—Median sagittal section of Block 1 which includes the lower part of the umbilicus, the upper border of the exstrophic parts and the intervening tissue: *a*, skin over umbilicus; *b*, mucous membrane of furrow; *c*, *c'*, transitional epithelium over the upper border of the exstrophy; *d*, rectus abdominis; *e*, right umbilical artery.

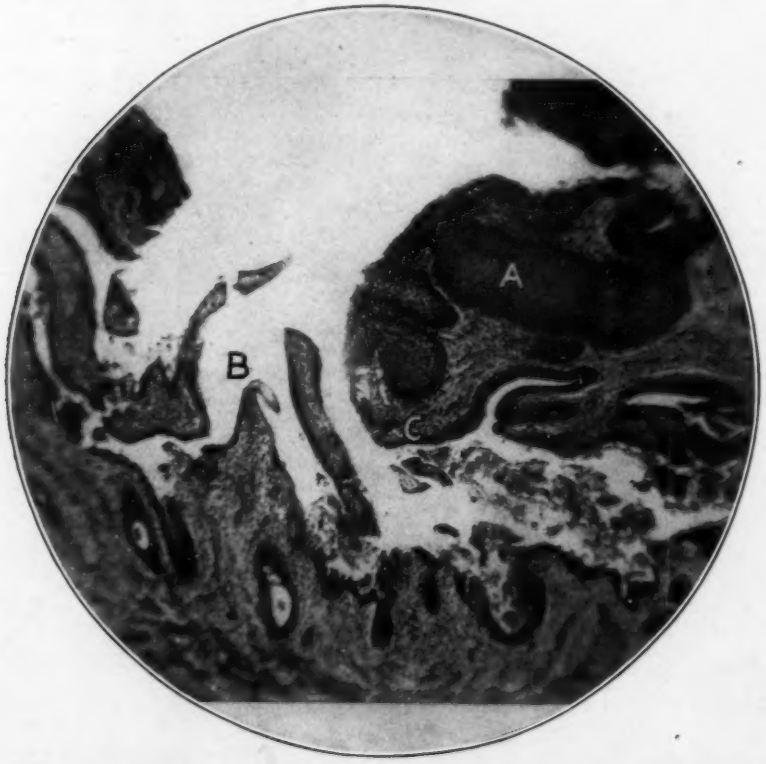

Fig. 8.—Section shown in Figure 7, showing the change from stratified squamous epithelium to the transitional type: *A*, mucous membrane of furrow; *B*, transitional epithelium over the upper border of the exstrophy; *C*, point where the change of epithelium occurs. (Oc. 2; obj. A. [Zeiss]; bellows, 8 inches.)

cut as nearly as possible in the median sagittal plane (Fig. 7). The fibers of the rectus abdominis are shown in transverse section. This is due to the marked diastasis below, so that above the exstrophic parts, the fibers assume an almost transverse direction to reach the linea alba. The right umbilical artery also courses transversely as it reaches the umbilicus (Fig. 5).

The epithelium of the umbilicus is stratified squamous epithelium with a well marked stratum corneum. Below the umbilicus, the stratum corneum is lost or poorly defined and the stratum germinativum becomes much wider. This area represents a furrow covered with mucous membrane, which separates the skin from the exstrophic parts. At the upper border of the exstrophic parts,

Fig. 9.—Section shown in Figure 8, higher magnification and different slide. (Oc. 2; obj. A [Zeiss]; belows, 21 inches.)

the epithelium changes to the transitional type, which is thrown into villus-like rugae. At the point of change, the epithelium is intermediate between transitional epithelium and stratified squamous epithelium. Figure 8 shows the types of epithelium noted, and Figure 9 shows a more highly magnified photomicrograph of the same region in another section.

Block 2: The central portion of the exstrophic parts surrounding the intestinal opening and the terminal part of the small intestine. A median sagittal section is shown in Figure 10. The mucosa of the small intestine is well defined near the terminal opening. The villi are enlarged and closely packed. Goblet cells predominate. The intestinal glands also contain many

goblet cells but less than the villi. At some distance from the terminal opening, the villi have been destroyed to a great extent, and only the short crypts of the glands remain.

The mucosa surrounding the intestinal opening presents no villi; but these have evidently been destroyed, for they are present in a protected depression at *b*. Villi are also noted at *b'*, but beyond these points the mucosa changes to that characteristic of the large intestine. The crypts of Lieberkühn vary

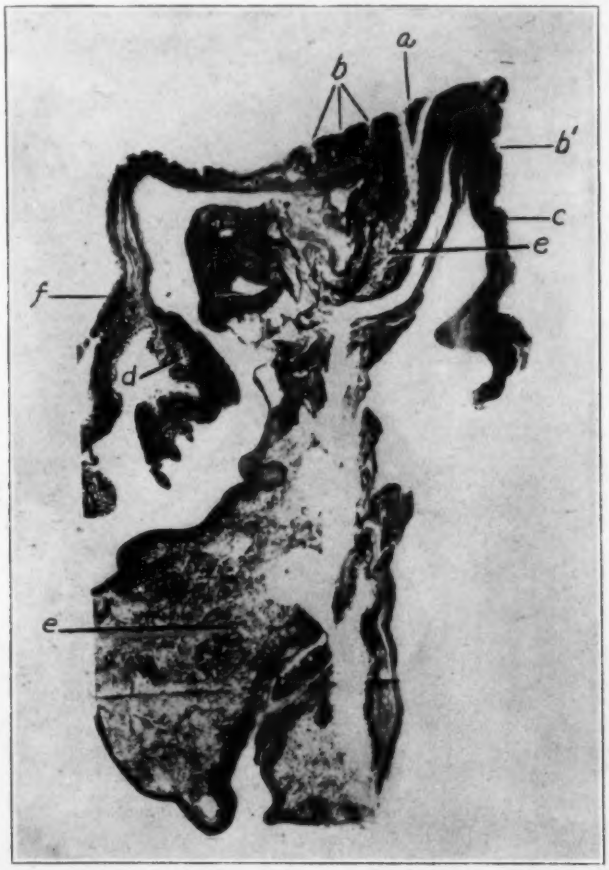

Fig. 10.—Section through the terminal part of the small intestine and the adjacent portion of the exstrophic parts: *a*, intestinal opening; *b*, *b'*, mucosa typical of small intestine; *c*, *f* and *d*, areas corresponding to Figures 11, 12 and 13, respectively. In all, the mucosa is typical of that of the large intestine.

markedly in depth. Figure 11 shows the mucosa at *c* of Figure 10. The mucosa is characteristic of that of the large intestine. The submucosa and part of the muscularis is shown. Goblet cells are abundant. Figure 12 *d* shows the mucosa of Figure 10. Here all the tunics are represented. The submucosa varies in thickness and the muscularis does not enter the folds. At *f*, Figure 10,

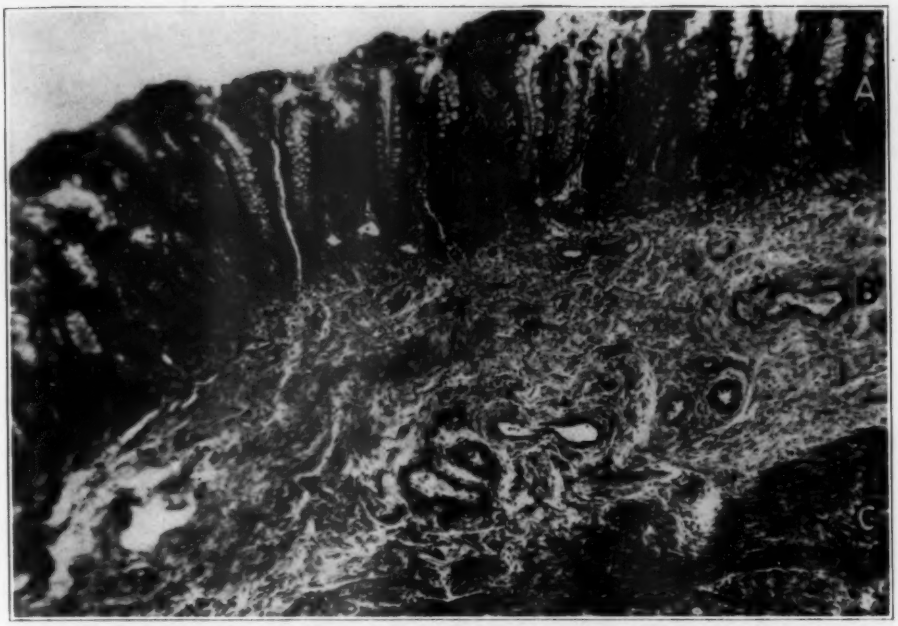

Fig. 11.—Section corresponding to *c*, Figure 10. The mucosa shows the crypts of Leiberkühn and the absence of villi: *a*, mucosa; *b*, submucosa; *c*, muscularis. (Oc. 2; obj. A [Zeiss]; bellows, 14½ inches.)

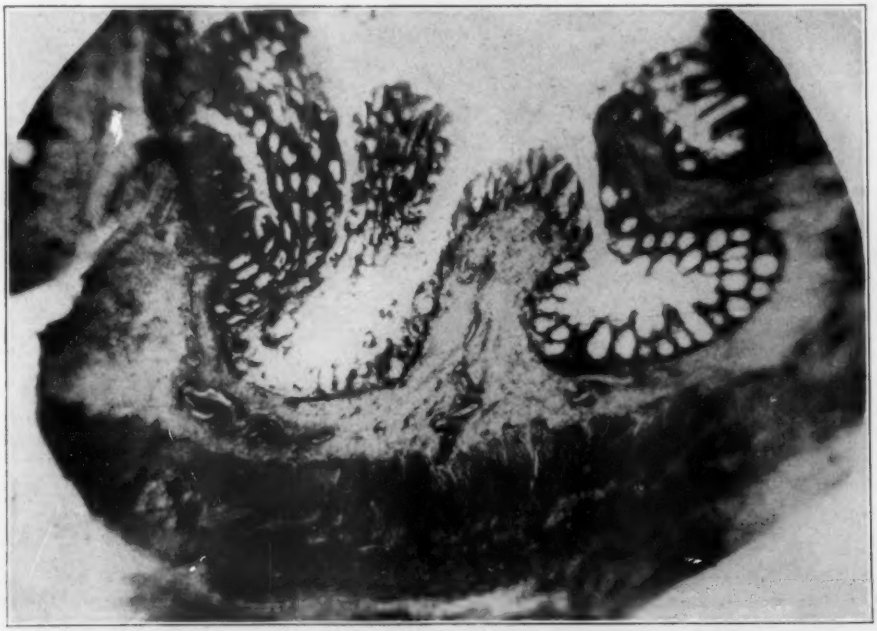

Fig. 12.—Section corresponding to *d*, Figure 10. Lower power of magnification, showing the intestinal tunics. The submucosa varies in thickness and the muscularis does not enter the folds. The mucosa is typical of that of the large intestine. (Oc. 2; obj. 1 [B & L]; bellows, 10 inches.)

the crypts of Lieberkühn are cut transversely. Figure 13 shows a high magnification of these crypts, with the preponderance of goblet cells.

Block 3: One of the larger columnar elevations of the central portion of the exstrophic parts. Figure 14 represents a median section which shows a mucosa characteristic of large intestine, a well developed submucosa and a muscularis. At *a*, the crypts of Lieberkühn are relatively long (compare Fig. 15), while at *b*, they are shorter (compare Fig. 16). Goblet cells are abundant. The muscularis is well defined, and is divided into an inner circular and an outer longitudinal layer.

Block 4: Transverse section near the basal attachment of the penis. In the section, it is shown that the transverse diameter is about twice as long as

Fig. 13.—Section corresponding to *f*, Figure 10; Leiberkühn's crypts in transverse section. (Oc. 2; obj. E [Zeiss]; bellows, 16 inches.)

the cephalocaudal diameter (Fig. 17). The epithelium of the caudal surface is true skin as is shown by the well developed stratum corneum, the sweat glands and a few scattered sebaceous glands. On the umbilical surface, the stratum germinativum is relatively thicker and the stratum corneum is absent. No sweat glands or sebaceous glands are present.

The corpora cavernosa (*a*, *a'*) are widely separated, and lie nearer the umbilical than the caudal surface. The corpus cavernosum urethrae is triangular in section, with its base close to the umbilical surface and its apex lying between the corpora cavernosa.

The organ is otherwise solid and made up of fibrous tissue.

Fig. 14.—Protuberance of central portion of exstrophic parts below the intestinal opening: *a* and *b* are parts of the mucosa shown in Figures 15 and 16, respectively; *c* and *c'* show the longitudinal layer of the muscularis.

Fig. 15.—Section corresponding to *a*, Figure 14. Mucosa and part of submucosa are shown. The crypts of Leiberkühn are relatively long. (Oc. 2; obj. A [Zeiss]; bellows, 14¼ inches.)

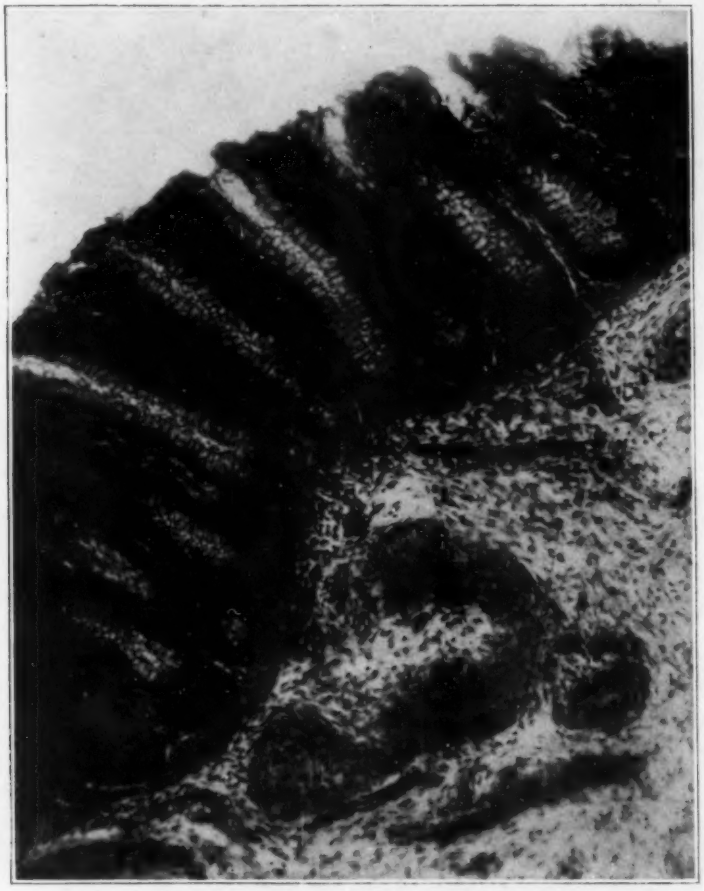

Fig. 16.—Section corresponding to *b*, Figure 14. Mucosa and parts of submucosa are shown. The crypts of Leiberkühn are relatively short. (Oc. 2; obj. A [Zeiss]; bellows, 14½ inches.)

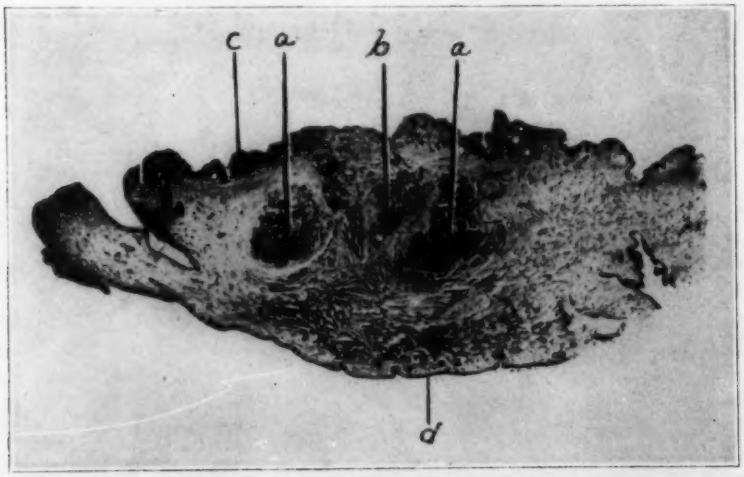

Fig. 17.—Transverse section of penis near its basal attachment: *a*, *a'*, corpora cavernosa; *b*, corpus cavernosum urethrae; *c*, mucous membrane covering the umbilical surface; *d*, skin over the caudal surface.

Block 5: Right lateral mass, including the terminal portion of the common duct of the vas deferens and the ureter. Figure 18 is a longitudinal section of the common duct and shows the adjacent tissue of the lateral mass around the opening. The epithelium of the common duct has been destroyed and its type could not be determined. The epithelium of the adjacent lateral mass is of the transitional or urogenital type. The superficial cells have been destroyed and are covered with incrustations of urinary salts; but in the protected crypts, their character could be determined with certainty. In favorable areas, two layers can be recognized: a deeper layer made up of clubbed shaped cells with a fairly deeply staining cytoplasm and rounded deeply staining nuclei,

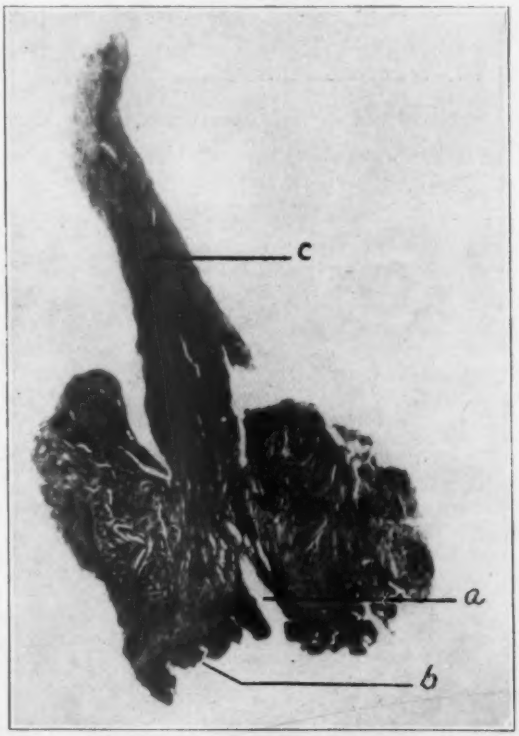

Fig. 18.—Distal end of common duct of vas deferens and ureter and the adjacent part of the lateral mass: *a*, opening of common duct; *b*, surface of lateral mass covered with transitional epithelium; *c*, common duct.

and an outer single layer of larger cells, with a less deeply staining cytoplasm and larger round nuclei with more scattered chromatic elements. The epithelium, which is extremely irregular, is arranged in folds of varying size with deep invaginations between them, giving it a villous appearance. There is a marked round cell infiltration beneath the epithelium, with many polymorphonuclear leukocytes. The muscularis is made up of bundles which run in various directions, so that no definite layers can be distinguished.

Block 6: Sections from the upper half of the left lateral mass. These sections show the same type of epithelium as was noted in Block 5. In some areas,

Fig. 19.—Transverse section of right diverticulum: *a*, *a'*, *a''*, lymph nodules in the tunica propria.

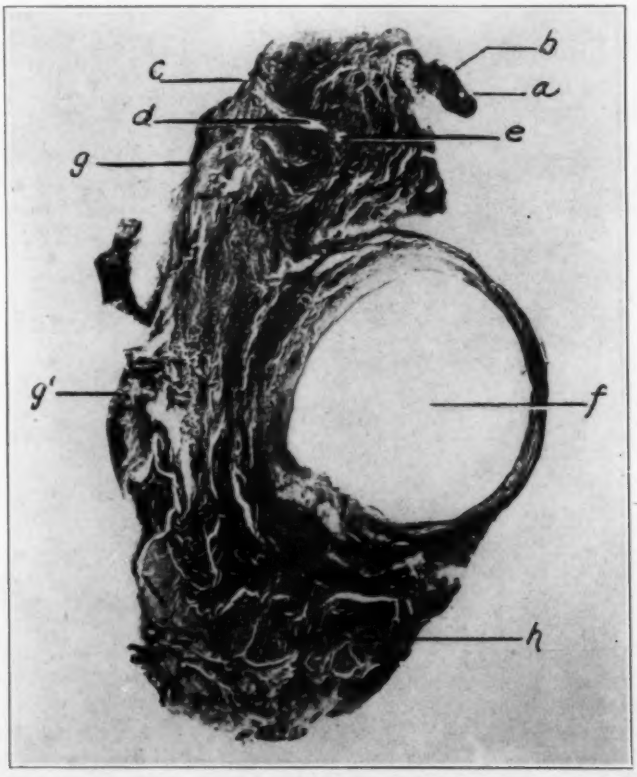

Fig. 20.—Median sagittal section below the central portion and including the perineal structures: *a*, lower edge of central portion invested with mucosa of large intestine; *b*, upper part of central bar invested with transitional epithelium; *c*, area at which the prostatic ducts empty; *d*, large dilated prostatic duct; *e*, prostatic glands; *f*, prostatic cyst; *h*, perineal muscles; *g*, *g'*, the base of the penis, which has been cut off.

it has been entirely denuded and covered with incrustations of urinary salts. In the crypts or furrows, the character has been well preserved. As in the other block, the evidence of inflammation, due to infection, is quite marked.

Block 7: Cross section of the right diverticulum (compare Fig. 5). The section shows this hollow viscus with its lumen and the thin wall. The latter has a well developed muscularis submucosa and mucosa (compare Fig. 19). This mucosa is characteristic of that of the large intestine. The crypts of Lieberkühn are much shorter than those found elsewhere. In the tunica propria, there is an infiltration of lymphocytes. At intervals, the lymphocytes are so densely packed as to form nodules which extend into the submucosa, but which do not reach the muscularis. No germinal centers are noted. The tunica muscularis is divided into an inner circular and an outer longitudinal layer.

Block 8: Lower border of the central portion of the exstrophic parts, the central bar and the adjacent perineal and pelvic structures. The penis has been removed at its base. This block includes the cyst noted in the dissection.

The median sagittal section shown in Figure 20 includes the structures mentioned. Unfortunately the epithelium has been partly destroyed, but enough has been left intact so that reconstruction is possible. At *a*, which is the lower border of the exstrophic parts, the epithelium is characteristic of that of the large intestine. At *b*, a fairly abrupt change occurs, and the epithelium is of transitional or urogenital type. At *c*, the epithelium is of the transitional type, and a number of ducts, which communicate with deeply lying alveolotubular glands, open here. These ducts, which vary in size (a large one is noted at *d*), are lined with stratified cuboidal epithelium. The glands are lined with a single layer of cuboidal or columnar cells. They vary considerably in size and shape, and are separated for a considerable distance by connective tissue and smooth muscle fibers. These glands undoubtedly represent those of the prostate, which has not been developed sufficiently to form a well defined organ with a capsule.

The nature of the cyst, *f*, is in doubt, since no epithelial lining is present. Its wall is composed of fairly compact fibrous tissue. From its position, it is possible that it may be a prostatic cyst, but there is no evidence on this point. Between *g* and *g'* is a cut surface representing the basal attachment of the penis. The perineal muscles are shown at *h*.

Sections were cut from all the other important organs but no deviation from the normal was noted.

IDENTITY OF THE EXSTROPHIC PARTS AND RELATED STRUCTURES

From dissection of the specimen and a comparison of most of those previously described in the literature, it is evident that in all cases there is an exstrophy of a retained cloaca. The retention of this embryonal structure is shown by the entire absence of the large intestine and the presence of a mesonephric duct (common duct for the vas deferens and ureter.) Although the cloaca has undergone comparatively little change in its general appearance, those areas that were destined to form fetal structures have shown their intention by the character of their epithelial investment. Thus, the lateral masses and the tissues which connect them above and below represent the urogenital sinus, which is the anlage of the urinary bladder, and is therefore covered with transitional or genito-urinary epithelium. The central portion of the

exstrophic parts, which represents the anlage of the large intestine, is covered with epithelium characteristic of that of large intestine, as one would expect.

The diverticula which empty into the lower part of the central portion of the exstrophic parts have no fetal homologues, nor have the embryonal structures of a similar nature been described. In all the specimens previously described, except one, these diverticula are present and empty into a blind bowel, which, in turn, empties into the lower part of the central portion of the exstrophic parts. The specimen here described is unique in that the diverticula have separate openings, and

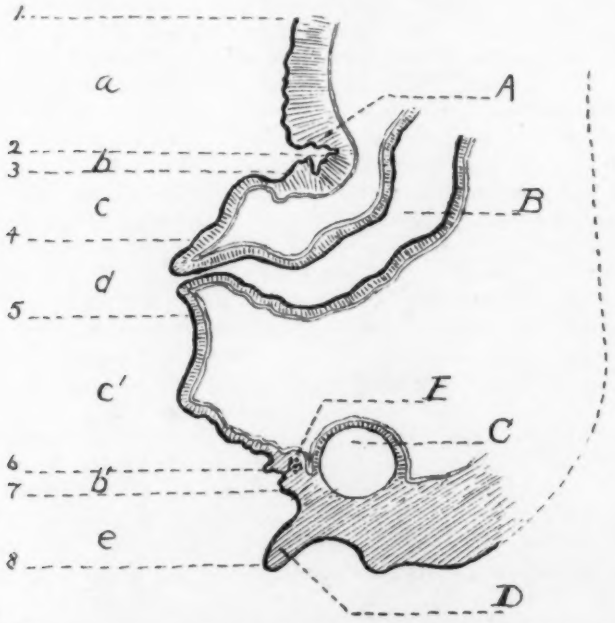

Fig. 21.—Diagrammatic median sagittal section of complicated exstrophy (cloacal exstrophy), showing the types of epithelium: *a*, (1-2), skin; *b*, (2-3), mucosa characteristic of colon; *d*, (4-5), mucosa characteristic of small intestine; *c'* (5-6), mucosa characteristic of colon; *b'* (6-7), transitional epithelium; *e* (7-8), mucous membrane; *A*, umbilicus; *B*, small intestine; *C*, prostatic cyst; *D*, penis; *E*, prostatic glands.

the blind bowel, found so constantly in others, is represented by a short culdesac. The blind bowel so constantly present has been called the large intestine by all previous writers, but the diverticula which empty into it have been variously designated.

The fact that this blind bowel, which lies in the pelvis and turns cephalad on the sacrum, is almost invariably present, and that it has never been found communicating with the anus indicates that this

structure is probably the embryonal postanal gut. (This point will be more fully discussed later.) The diverticula, which in nearly all of the specimens previously described empty into the blind gut, and which in the specimen here described assume separate openings, are probably structures which are normally associated with the postanal gut but which have hitherto been overlooked. These structures must necessarily be insignificant in size in the normal embryo, and so, readily overlooked, but they would attain a considerable size in a full-term fetus in which a postanal gut and a cloaca were retained.

The genital tab represents a penis with a marked epispadias. This is shown by the well developed corpora cavernosa and corpus cavernosum urethrae. The umbilical surface is the open urethrae, as is shown by the character of its epithelium. It is directly continuous with the central bar of the exstrophic parts, which represents the prostatic urethra, since the prostatic ducts empty here and the epithelium is transitional in type.

A median sagittal section through the exstrophy is shown in Figure 21. This gives, roughly, the general outline and types of epithelium encountered. The epithelium of the entire exstrophic region, the central bar and the umbilical surface of the penis are derived from entoderm.

CLASSIFICATION AND REPORTED CASES

Keith [2] has divided these malformations into four groups: 1. Ectopia vesicae in the male. 2. Ectopia vesicae in the female. 3. Ectopia vesicae combined with a fistulous condition in the intestines. 4. Epispadias. The third group is represented by eight cases, five female and three male, in the Museum of the Royal College of Surgeons, and four male and two female from museums of various metropolitan schools. He states that the specimens are nearly all alike, in that the ileum and so-called cecum enter what he calls a Meckel's diverticulum or yolk sac. The rectum is imperforate, the appendix occasionally bifed, a proctodeum usually present and a spina bifida present without exception. The orifices of the Wolffian duct may be occluded, or the ureter may open into the latter. When these do not unite, they open separately on the crescentic shaped trigon. The testes are always undescended.

Frederick Wood-Jones [1] described two other cases of this type. He also emphasizes the fact that a strong similarity exists and that a description of one case would apply to all. In these grave cases, he

2. Keith, A.: Three Demonstrations on Malformations of the Hind End of the Body, Brit. M. J. **2**:1857 (Dec. 26) 1908.

states, the infants die soon after birth, and most of them are born prematurely. Many are born dead and one month is longer than the average life. He writes:

> All of these cases agree in having two openings upon the exposed red central lobulation of the lower abdomen: the upper opening leading to the small intestine (which is usually prolapsed some distance through the orifice) and the lower one leading to the large intestine.
>
> The large intestine shows one of the most remarkable and one of the most constant of the series of anomalies exhibited by these cases; for immediately within its openings, two orifices lead into two separate and well developed appendices. The anterior opening of the large intestine is the only opening that the hind gut possesses, for it ends blindly caudad as a culdesac in the pelvis. At times, a proctodeal depression is formed, but this is not constant. The testicles remain in the abdomen in the males, and the genital duct and the ureters usually have a common opening on the surface, below and lateral to the orifice of the large intestine.
>
> In many cases, one kidney is of strikingly abnormal form, erring on the side of over, rather than under development. A sacral spina bifida is always present, and is always accompanied by a large syringomyelocele. The genital tubercle is a mere rudiment, and such development as is shown is that of a condition of epispadias, the dorsum being laid open completely.
>
> The pubic bones of the opposite sides do not meet in the midline at a symphysis, a feature which is shown by incomplete or "simple" cases of ectopia, and even some cases of epispadias. There is sometimes, but not in typical cases, a well marked kink in the dorsal region of the fetus, so that the whole body is flexed backward in a position of opisthotonus.

In the two cases which he examined, the testes lay against the kidneys and the genital ducts opened, in common with the ureters, as slitlike orifices below and lateral to the openings of the so-called large intestine. Well developed cecums or paired appendixes were also noted in both cases. In his second case, the right kidney was larger than the left; which, he states, indicates a reptilian character. The genital tubercle was very small, and a large syringomyelocele, with a grooved prominence on the anterior surface, was present. The umbilical arteries ran to the cephalic end of the exstrophy.

Wood-Jones [1] characterized the simple and complicated cases of exstrophy under Keith's classification as shown in the accompanying table.

He [1] believed that these complicated exstrophies are the gravest manifestations of some process the effects of which are also seen in the uncomplicated cases and even in epispadias. He offers the following classification of these abnormalities: (1) simple epispadias (penile urethra only involved; incontinence may be only partial); (2) epispadias with failure of development of symphysis (incontinence absolute); (3) epispadias of type "subsymphysial vesical exstropy" of Ballantyne, in which not only the penile urethra but also the prostatic portion, and even the inferior area of the bladder, becomes exposed by the absence

of the anterior wall; (4) ordinary simple extroversion of the bladder, in which the whole bladder area is exposed, and (5) complicated or cloacal extroversion: ectopia vesicae of Group 3 of Keith's, in which two intestinal openings are also present on the exposed surface.

T. B. Johnston [3] recorded a case of exstrophy, complicated by intestinal openings, in a seven months female infant that lived for three days. He found an umbilical cord of normal appearance situated 8 cm. from the xiphisternal junction. The left umbilical artery was absent. A small intestine opened 3 cm. caudad to the umbilicus; and 5.5 cm. caudad, there was a button-like elevation which could be readily invaginated to form a blind diverticulum. At the caudal edge of this diverticulum was a slitlike opening leading into the large intestine. The latter passed backward and downward into the pelvis for 3 cm., and ended blindly. No paired appendixes were found. There was a proctodeal depression.

Simple and Complicated Cases of Exstrophy (Keith's Classification)

GROUP I	GROUP III
1. No intestinal opening	Two intestinal openings
2. Normal anal opening	Imperforate rectum
3. Spinal cord normal	Spina bifida
4. Separate opening of ureter and vas deferens	Union of vas deferens and ureter
5. Testes inguinal or scrotal	Testes undescended
6. Trilobed appearance of exstrophic parts	Trilobed appearance of exstrophic parts
7. Genital tubercle cleft dorsally	Genital tubercle cleft dorsally
8. Symphysis pubis, incomplete	Symphysis pubis, incomplete.

At the caudal edge of the exstrophic parts was a taglike elevation resembling a small clitoris. There was failure of complete axial rotation of the "intestines." The uteri were separated and the vaginas connected by an impervious fibromuscular bridge at the lower ends. The left vagina did not open on the surface. A spina bifida was not present. Johnston [3] does not agree with either Keith or Wood-Jones [1] that the complicated cases of exstrophy show any marked similarity, for his case presented neither the spina bifida nor the paired diverticula.

Allan Doran,[4] in 1881, presented an interesting case of complicated exstrophy in a female fetus. It showed the following anomalies: a retroflexion of the spine, spina bifida, exstrophy of the bladder, ectopia

3. Johnston, T. B.: Extroversion of the Bladder, Complicated by the Presence of Intestinal Openings on the Surface of the Extroverted Area, J. Anat. & Physiol. **48**:89 (Oct.) 1913.

4. Doran, A.: Dissection of the Genito-Urinary Organs in a Case of Fissure of the Abdominal Wall, J. Anat. & Physiol. **15**:226 (Jan.) 1881.

viscerum and a short umbilical cord. The stomach and intestines were held by a simple mesentery, and the small intestines were several inches in length and opened into the exstrophy just below the umbilicus. A canal extended from the lower part of the exstrophy to an opening in the left groin. The openings of the ureters were impervious, and the ureters and kidneys were dilated.

The presence of a tube from the caudal part to the left groin is a condition which has not been described in any other recorded cases; and although its identity is not certain, it seems probable that it represents what Keith,[2] Johnston [3] and others have called the large intestine. Its opening in the groin is most difficult to explain, but its position, at least, would cause one to hesitate before calling this and similar structures the large intestine. This point will be discussed later.

Sequeira,[5] in 1896, presented a case of this type in a full-term female infant that died four days after birth. It presented in the lower part of the abdomen a triangular area of mucous membrane, with the umbilical cord at the apex. He believed that this mucous area was the open bladder, and he noted at its lower part a large funnel-shaped orifice which he called the patent vitelline duct, which led directly into the lower part of the ileum. This opening was large enough to admit the forefinger, and on each side the bladder wall was pushed forward as a large rounded protuberance. On the right protuberance were three orifices, the lowest slitlike, which communicated with the common urogenital duct. The middle, which was guarded by a liplike fold, communicated with a short blind tube, which he called the duct of Gartner. The upper orifice also led into a short blind tube, which he does not identify. On the left protuberance, two openings were noted: an inferior, which communicated with the genital (müllerian) duct and a superior or Gartner's duct, which ended blindly. The labia majora and the labia minora were represented by transversely placed folds.

The small bowel was 1.37 meters long. The duodenum, which presented no abnormality, ended in a small orifice in the so-called funnel-shaped vitelline duct at right angles. The lower part of the ileum, he stated, was at right angles to the upper, and seemed to be a direct continuation of the vitelline duct. The latter terminated in the large intestine. The large bowel, which was 11.2 cm. long, formed a single loop and ended blindly in the pelvis opposite the end of the coccyx. Just below the entrance of the so-called second part of the ileum were noted two diverticula, one of which, he believed, was the appendix and the other the cecum.

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5. Sequeira, J. H.: A Case of Ectopia Vesicae with Patent Vitelline Duct, J. Anat. & Physiol. **30**:362 (April) 1896.

The kidneys lay on either side of the spine in the lumbar region. The right was large, and was surmounted by a somewhat flattened suprarenal. The left was small and atrophic, and was surmounted by a suprarenal of the same size.

Each ureter communicated directly with the corresponding genital duct (müllerian).

There was at each portion of the genital duct a rudimentary uterus with its adnexa. The pubic bones were widely separated. The body was normal in other respects, except for a spina bifida.

Bryce,[6] in 1895, described a male fetus of seven months. The trunk was acutely retroflexed, with its center in the lumbar region. There was a marked spina bifida extending along the whole concavity of the back. The pubic bones were widely separated. The thighs were rotated at the hipjoints so that the extensor surface looked outward. The right foot showed a slight degree of talipes valgus. The head, neck and thorax were well formed. The abdominal wall was widely cleft, beginning at 2.5 cm. from the subcostal angle and reaching at its greatest divergence the ventral end of the pelvic girdle. The abdominal viscera lay entirely outside the body wall in a membranous sac, which was continuous with the free edge of the body wall. The amnion was continuous with this membranous sac near the center of the placenta. There was no umbilical cord. At the caudal part of the sac, this membrane formed two folds, between which was an oval area, the upper part of which was bright red and covered by a mucous membrane, and the lower continuous part, thin and membranous. In the middle of this area lay an elevated column, which was firm and fleshy and attached along its whole base. Immediately below this, but separated from it by a tiny yellow nodule with a depressed center, was a vertical slit 9 mm. long, which opened into the space containing the viscera. On the lateral parts, also overlapped by the membranous folds, there were two small ridges, on which were placed two pin-point apertures, the openings of the ureters. The anal pit was patent and passed directly, to the extent of 1 cm., toward the red area. The genital organs, as such, were absent.

In the dissection, the spleen was found to have no parietal connection. The intestines were primitive beyond the duodenum and attached by a medial mesentery. There was no colonic loop, cecum or appendix. There was no trace of a vitelline stalk The intestine emptied into the vertical slit heretofore described.

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6. Bryce, T. H.: Description of a Fetus, the Subject of Retroflexion of the Trunk; Ectopia Viscerum and Spina Bifida; with a Discussion as to the Cause of These Associated Abnormalities, J. Anat. & Physiol. **29**:553 (July) 1895.

Bryce also described a sac measuring 3.2 by 1.3 by 2.3 cm., which was attached above the intestines, the border of which was irregular, lobulated or constricted at intervals, to which the mesentery was attached. Unfortunately, Bryce's description is so vague that it is impossible to follow him.

Dakin,[7] in 1890, described a fetus, one of twins, with retroflexion of the spine, spina bifida, ectopia viscerum and absence of the umbilical cord. Exstrophy of the bladder was not mentioned. The mother later gave birth to an eight months fetus presenting a spina bifida, talipes varus, eversion of the knees, cleft palate and absence of the anus. The alimentary tract presented no abnormality down to the large intestine. The latter was found to enter posteriorly a large cyst, which he believed was a markedly distended bladder. Four openings were noted entering the inner surface of this cyst. Three were on the posterior wall, and the fourth, which he believed was the urethra, entered the inferior surface. There was a small, rudimentary but formed, penis, which contained a urethra into which a bristle could be passed. An epispadias was evidently present, although not mentioned, for the illustration of this specimen shows the bristle exposed at the base of the penis. A bristle could also be passed under the pubes through the proximal portion of the urethra into the cyst, a distance of one and a quarter inches.

The three other openings on the posterior wall were close together. One was connected with a blind sac, which was considered the prostatic cavity, since the seminal ducts emptied on either side. The two remaining openings represented the opening of the gut and of the ureter, respectively. No right kidney or ureter was present, and the left kidney was hydronephrotic, with an undilated ureter.

This case, although not mentioned among the complicated cases of exstrophy of the bladder, presents a number of malformations commonly associated with this condition worthy of later discussion. The description is, unfortunately, vague and inaccurate.

In 1906, Emrys-Roberts and Paterson[8] reported the case of a still-born full-term infant, presenting spina bifida and ectopia viscerum. The father died at 32, of tuberculosis accelerated by alcoholism. The mother was 30 and healthy. The previous children were all healthy. The placenta and infant were born simultaneously. Unfortunately, the description is vague and the nomenclature of the malformations

7. Dakin, W. R.: Dissection of a Fetus, the Subject of Retroflexion, Ectopia Viscerum, etc., with Remarks on the Frequent Association of These Abnormalities and Its Cause, Obst. Tr. **32**:200, 1890.

8. Emrys-Roberts, E., and Paterson, A. M.: A Case of Ectopia Viscerum, Associated with Spina Bifida and Other Abnormalities, J. Anat. & Physiol. **40**:332 (July) 1906.

peculiarly restricted to the specimen, so that it is impossible to follow it. The illustrations add to the confusion. The infant, however, presented the following malformations: the trunk was in opisthotonus and there was a marked spina bifida in the lumbosacral region; in the middle of the perineum was a blind proctodeal depression, and attached to the groin were the so-called genital papillae, the left pedunculated, and the right, a sessile elevation.

The amnion, which was attached along an oval margin extending from the thorax to the lower part of the abdomen, formed a large sac attached to the placenta. It contained the abdominal viscera, pericardium, heart and left lung.

Above the proctodeal depression was a longitudinal oval opening communicating with a cavity called the internal cloaca, which, in turn, communicated anteriorly with what Emrys-Roberts and Paterson called a bladder-like dilatation, and cephalad with a large cavity which they designated as the cecal pouch. This so-called cecal pouch communicated with the so-called bilateral appendixes, and also with the small intestine. They noted besides, a defect in the diaphragm, an absence of the left umbilical artery and a wide septum of the pubic bones. No genital organs were noted.

It is quite possible that, in this specimen, the so-called cecal pouch and the bladder-like dilatation represented the cloaca, which had, because of the small sized external opening, failed to invert and protrude.

In 1865, Förster[9] described a number of cases of exstrophy of the bladder, including the complicated type, and, in 1880, Ahlfeld[10] described the cases of Meckel and Rose. In 1900, von Steinbuchel recorded a case of this type. I have been unable to obtain these case reports.

THEORIES OF CAUSATION

Many theories have been advanced to explain the cause of exstrophy of the bladder and its allied malformations, and those interested in the subject I refer to the paper of F. Gregory Connell,[11] who brought the subject up to date in 1901. For a review of the subject with particular emphasis on the etiology of the complicated exstrophies of the bladder (ectopia cloacae), the paper of T. B. Johnston[3] is recommended. He discusses the previous theories in their chronological order, and adds a theory of his own which is a marked advance over the theories of earlier writers.

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9. Förster, A. Die Missbidungen des Menschen, Jena, 1865.
10. Ahlfeld, F.: Die Missbildungen des Menschen, Leipzig, 1880.
11. Connell, F. G.: Exstrophy of the Bladder, J. A. M. A. **36**:637 (March) 1901.

Before taking up the previous theories of etiology, it is well to emphasize that a number are based on misconceptions regarding the embryonal development of the intestinal and urogenital tracts. In practically all, a histologic study of the tissues has been omitted. The difficulty is increased by a failure to identify the malformed structures, as is seen by comparing the nomenclature which the different observers have used to describe their respective specimens.

The various theories fall more or less generally into three classes, although a number of investigators have attempted to explain these malformations by correlating two or more of these classes. Roughly, the theories may be classed as the mechanical, the pathologic, and the theory of arrested development.

The mechanical theory may be divided into: 1. The "berstungs theorie" (rupture theory), which considers the cause of exstrophy of the bladder and epispadias as a rupture of the anterior wall of the bladder and the adjacent abdominal wall, due to a retention of fluids in the bladder. This retention is believed to be due to constrictions at various points along the genito-urinary tract. 2. The mechanical theory, which considers a short or absent umbilical cord as the causative factor. 3. A theory which is not based entirely on a mechanical conception, but depends on a transposition of the embryonal anlagen, and considers that the complicated exstrophies (ectopia cloacae) are due to a change in position of the vitelline duct. Some of the earlier writers on the subject have advanced the belief that direct injury is a causative factor.

Among those advancing the rupture theory may be mentioned Breschet, Raafe, Müller, Pokitanski, Rolgans, Morgelin, Duncan, Shutze and Weinkle (referred to by Connell). In general, it was believed that a constriction of the urethra or of the outlet of the bladder causes a distention of the bladder which separates the ends of the pubic bones and the recti abdominis, and that this finally causes a rupture of the anterior abdominal wall of the bladder and the weakened abdominal wall. Healing finally occurs along the edges.

In 1910, Wood-Jones [4] again advanced the "Berstungs theory." He stated that simple exstrophy of the bladder and also the complicated types with intestinal openings are due to distention of the bladder and final rupture of the anterior abdominal wall. He believed that the complicated types are due to rupture at an earlier period of embryonal development, and he compared these types to hydrocephalus and syringomyelocele. He believed, further, that the separation of the recti abdominis and the separation of the pubic bones can only be explained by a spaying of these structures, and as evidence he pointed out that there existed a distention of the urinary tract and a general thinning of the anterior abdominal wall. He believed that, in complicated types, an atavistic tendency is apparent, as is shown by the

paired diverticula of the so-called large intestine and that these structures represent the paired cecums of birds and reptiles. He pointed out that, in *Hyrax,* a similar example existed in the mammalia. Further examples of this reptilian character, he believed, are shown by the union of the vas deferens and the ureter, and by the character of the kidneys.

Brandl,[12] in 1913, advanced the rupture theory, basing his assumption on the experiments of Weiner (voiding of fetus before birth). He believed, that if the obstruction occurs in the bladder, distention of that organ will occur, with the separation of the pubic bones, and final rupture. The upward curve of the penis, he believed, is due to a cicatrical contraction, and its shortening, to the separation of the pubic bones. He stated that if the obstruction occurred in the penile urethra, rupture would occur in that organ, with a resulting epispadias.

The objections to the rupture theory were enumerated by Champneys [13] and Connell.[11] It is quite obvious that if this is a correct explanation, one should be able to demonstrate these so-called obstructions of the genito-urinary tract, but as far as is known this has not been done.

Another obvious objection is that rupture invariably takes place along the midline; whereas, if it is due to pressure, one might expect it to occur occasionally at some other location. Furthermore, since a small rupture would relieve the supposed pressure, it is difficult to explain the extensive rupture so often found.

The theory advanced by Ahlfeld,[10] Doran [4] and Keith [2] to explain the complicated exstrophies with intestinal openings assumes a displacement of the vitelline duct. None of these observers explained how it is possible for the vitelline duct to assume a position apart from the umbilical cord, although Wood-Jones [1] stated that fetal membranes have been found attached to the edge of the exstrophic parts. Johnston,[3] however, denied the existence of such membranes and called attention to the fact that a normal umbilical cord is often present. He stated that, if some observer at some later time should demonstrate an area of bladder epithelium interposed between the normal skin below the umbilical cord and the intestinal mucosa above the intestinal opening, the identity of these structures would be established beyond a doubt, and the contention that a vitelline duct occurs would also be proved false. In the report which I present, such an area of bladder epithelium has been demonstrated, verifying Johnston's [3] objection.

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12. Brandl, K.: A Contribution to the Study of Ectopia Vesicae, Am. J. Urol. **9**:333 (July) 1913.

13. Champneys, F. H.: A Case of Extroversion of the Bladder in a Female Child, with Dissection, St. Barth. Hosp. Rep. **13**:81, 1877.

The theory that a short umbilical cord produces changes in embryonal development is held by Ahlfeld [10] and Bryce.[6] The latter, according to Johnston,[3] believed that a short or absent umbilical cord was responsible for the retroflexion of the trunk occasionally met with and associated with these malformations. He ascribed the retroflexion as a moulding of the fetus to the contour of the uterine wall; but he gives no reason for the rupture of the anterior abdominal wall and the bladder, nor does he explain similar cases in which a cord of normal length is found.

In 1894, Shattock [14] advanced a theory that epispadias and exstrophy of the bladder are due to an abnormal upward extension of the cloacal cleft. He believed that the cleft produces a complete splitting of the penis and urethra, but that subsequent development causes a closure of the caudal edges of the cleft. He describes the altered relations of the corpora cavernosa to the urethra to the action of the ischiocavernosa and the bulbus cavernosus. Shattock studied some sections of the bladder wall in an exstrophy of that organ and noted ingrowths of epithelium which he likened to a precancerous phase.

The pathologic theory was advanced by Velpeau, Benjamin, Phillips, Chaussier and Wood.[15] The first two believe that ulceration of the anterior abdominal wall occurs and that this also occurs at the symphysis pubis, with subsequent necrosis and separation. Wood [15] found adhesion of the anterior abdominal wall to the fetal membranes "due to inflammatory or degenerative processes arising from specific diseases, such as syphilis." Keith [2] also advanced a pathologic theory, but his description is extremely vague and difficult to follow and his terminology is not that generally used. One gets the impression, however, that he believed that toxins from an endometritis may produce a separation of the lateral walls of the caudal portion of the embryo.

There is no evidence that the pathologic theory advanced by Velpeau and Phillips is plausible, for ulcerations of the anterior abdominal wall and bladder would be recognizable, and necrosis of the ends of the pubic bones would be plainly evident.

Keith's [2] suggestion that an endometritis may be the underlying cause of these malformations is certainly not verified by clinical evidence; but, as will be shown later, considerable experimental evidence has been brought out to give considerable weight to his assumption.

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14. Shattock, S. G.: Ectopia Vesicae, Tr. Path. Soc. London **38**:170 (Feb.) 1887; Specimens of Epispadias and Extroversion Vesicae, Showing an Attachment of the Muscular Wall of the Bladder to the Back of the Pubic Bones, etc., Tr. Path. Soc. London **45**:47 (April) 1894.

15. Wood, J.: On Fission and Extroversion of the Bladder with Epispadias, Tr. Medico-Chir. **52**:85 (Feb.) 1869.

The theory of arrested development has many adherents. Among the earlier ones are Geoffrey St. Hilaire and Vrolik, who called attention to the coexisting malformations, such as cleft palate, umbilical hernia, spina bifida, absence of one umbilical artery and defective development of the external genitalia. Reichel ascribed as a cause an arrested development occurring during the first week of embryonal life, which results in a disturbance in the formation of the primitive streak and a failure of coalescence of the borders of the primitive groove, with subsequent defective development.

Förster,[9] in 1865, ascribed an arrest in development as the cause for epispadias and simple exstrophy of the bladder, and also for the complicated types with intestinal openings. He believed that the arrest occurred as early as the third or fourth week of embryonal life.

Champneys,[13] in 1877, firmly supported the theory of arrested development. Unfortunately, he had no accurate knowledge of the normal development of the bladder, for he believed that this organ arises from the allantois and that the latter structure arises from bilateral anlagen. He believed that the arrest in development prevented the two "allantoic diverticula" from uniting. Since the bladder does not arise from the allantois but from the cloaca, it is evident that Champneys had no conception of the cause of these malformations.

Emrys-Roberts and Paterson,[8] in 1906, concluded that exstrophy of the bladder and the allied malformations are due to a failure in the development of the hinder portion of the alimentary canal. They believed that the arrest occurs after the formation of the cloaca.

In 1913, T. B. Johnston [3] described a female fetus with exstrophy of the bladder complicated by the presence of intestinal openings. His specimens differed from many of the others previously described in that there was no spina bifida and the appendixes or diverticula of the so-called large intestine were absent. He therefore concluded that these cases did not show any particular similarity. Johnston [3] agreed with Champneys [13] that any explanation for the cause of these malformations must take into account the normal development of the bladder and the lower end of the alimentary tract. He accepts as true the embryologic development as described by Keibel [16] and Pohlman.[17] He further stated that the cloaca gives rise to a greater part of the alimentary tract than heretofore supposed, and he believed that the terminal portion of the ileum and the entire large intestine are derived from this structure. He draws the following conclusions:

Epispadias is due to rupture of the urogenital part of the cloacal membrane at a site cephalad instead of caudad to the genital tubercle.

16. Keibel, F.: Zur Entwickelungsgeschichte des menschen Urogenitalapparates, Arch. f. Anat. u. Entwcklngsgesch., Leipzig, p. 55, 1896.

17. Pohlman, A. G.: The Development of the Cloaca in Human Embryos, Am. J. Anat. **12**:1-26 (July) 1911.

Pure extroversion of the bladder, complicated by intestinal openings on the extroverted area, is due to rupture of the cloacal membrane. This rupture may occur at any time between the first appearance of the membrane and the subdivision of the cloaca. The period at which this takes place will determine the variety of the anomaly; thus, it is suggested that the rupture occurred very early in the case recorded in this paper [Johnston's case] and at a later period in the case described by Emrys-Roberts and Paterson.

Spina bifida and paired diverticula at or near the surface orifice of the large intestine are not constant features of extroversion of the bladder complicated by intestinal openings on the extroverted area.

The primitive hind-gut gives origin to a much larger part of the alimentary canal than is generally supposed; whereas, the mid-gut forms very much less than is usually ascribed to it.

In his first conclusion, which is not discussed in his paper, he gives an erroneous impression, for if all cases of epispadias are due to a rupture of the urogenital membrane at a site cephalad instead of caudad, it would follow that the corpora cavernosa would always lie caudad to the urethra. This is not true in the cases of epispadias limited to the shaft of the penis, where the cleft divides the corpora cavernosa.

His second conclusion invites the same objections as his first, and may be true only to a certain extent.

His third conclusion assumed a rupture of the cloacal membrane at an early period of embryonal development, with the exposure of the undifferentiated cloaca to explain the cases with intestinal openings. He believed that this rupture prevents further division of the cloaca. His explanation certainly coincides with the anatomic findings and our knowledge of the embryologic development of these parts, and cannot be disproved. He suggests, further, that the time of rupture during embryonal development influences the degree of the malformation.

If he means to conclude that the cloacal membrane is ruptured along its entire length, he simply reiterates Shattock's [14] theory, and he must assume that the penis at one stage of its development is entirely split in half. This, of course, may occur in some cases, although we are not aware of them; but it is not the usual procedure.

His further assumption that the time of the rupture of the cloacal membrane influences the degree of the malformation is not necessarily true and certainly has no evidence to support it.

His fourth conclusion that paired diverticula and spina bifida are not constant features is true, but it must be admitted that his case is unusual in this regard. Since his specimen has no diverticula, he disregards these structures and offers no explanation for their occurrence in the other specimens. He does discuss the probable formation of the so-called large intestine, concluding that it is derived from the cloaca by a partial closure of the urorectal folds from below. He admits that this so-called large intestine may represent the postanal gut, as suggested by Keith [2] regarding the specimen described by Doran.[4]

Johnston [3] has successfully combated the theories previously advanced and has laid down a firm foundation for further study of these malformations. The objections to his own theory are only minor ones, and on the whole his theory is based on a sound knowledge of embryologic development. His attempts to solve this problem by a histologic study of the tissues are a marked advance over the attempts of earlier investigators.

ETIOLOGY OF EXSTROPHY OF THE BLADDER AND ALLIED MALFORMATIONS

It has been emphasized by both Keith [2] and Wood-Jones [1] that a strong similarity exists in complicated cases of exstrophy of the bladder (ectopia cloacae). My own specimen confirms this and creates a strong impression that there must be a common etiology for malformations of this type. With the exception of Johnston's [3] specimen, there was a spina bifida in every case, which suggests that the cause of these malformations may be of similar nature. The experiments of Morgan,[18] who produced spina bifida by subjecting frog eggs to the action of a 0.6 per cent. sodium chlorid solution, and those of Hertwig,[19] who obtained similar results with an 0.7 per cent. sodium chlorid solution, suggests that some chemical substance in the uterine mucosa, due to infection or otherwise, may be the inciting cause. Mall offers a similar suggestion for other types of malformations.

From the experiments of Morgan and Hertwig and the work of Tourneux, Martin [20] and Fischel [21] spina bifida must be viewed as the result of an arrest in development of the medullary plate, leaving the neural tube open.

It seems likely that a chemical substance, if such is present, has, in these complicated cases of exstrophy of the bladder (ectopia cloacae), caused not only an arrest in the middorsal region of the body, but also an arrest of the midventral region of the body. It further seems likely that the arrest has affected those parts which had not completed their embryonal development, and that when development recommenced, certain primitive embryonal structures were maintained and developed as such, and those which should have undergone differentiation, had no arrest occurred, failed to make these changes.

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18. Morgan: Ten Studies in Roux's Archives **15-19,** 1902-1905.

19. Hertwig, O.: Die Entwicklung des Froschies unter dem Einfluss schwächerer und stärkerer Kochsalzösungen, Arch. f. mikr. Anat. **39**:285, 1892; Eine vergleichende morphologische tratologische Studie an missgebildeten Froscheiern, Arch. f. mikr. Anat. u. Enkwcklngsgesch., Leipzig **44**:353, 1895.

20. Tourneux, F., and Martin, E.: Contribution a l'histoire du spina bifida, J. de l'Anat. et Physiol. **17**:1 (Jan.) 1881; **18**:283 (July) 1881.

21. Fischel, A.: Ueber Anomalien des zentralen Nervensystems bei jungen menschlichen Embryonen, Ziegler's Beitr. **41**:536 (Nov.) 1906.

It is noted that, in all the specimens described, there has been a failure of the lateral plates to meet at the ventral midline as shown by a separation of the pubic bones, and the recti abdominis. The assumption that this ventral separation and the occurrence of a spina bifida are due to an arrest is borne out by the normal development of the embryo, in which the caudal part assumes its tubular form later than the cephalic part. Such an assumption would also explain the retroflection of the body, since in the early forms, such as the C (3) Embryo Lg. of His's *Normentafel,* show a similar retroflexion.[22] It would also explain the degree of separation. The longer arrests would result in the development of severe types of ectopia viscerum with absence of the umbilical cord; the shorter, in simple ectopia vesicae and epispadias, and brief arrests, in epispadias alone. In all except the simpler types of epispadias separation of the pubic bones is invariably present.

By considering the arrest as having occurred before the tubular form of the embryo has been completed, an explanation is offered as to why the malformations are confined to the caudal part of the fetus. It would, after resuming development, finally complete the tubular form, but the caudal part would be broader than in the normal embryo, since the lateral plates would fail to meet in the midline. Consequently, all those bilateral structures which develop from the lateral body wall, and later meet in the midline, such as the ossa pubes and the halves of the scrotum, would fail to do so; and the unilateral midline structures occurring later, such as the genital tubercle, would be wider than in the normal.

The arrest would also explain the retention of the cloaca, the postanal gut and the common duct for vas deferens and ureter.

As previously stated, it is not believed that the postanal gut is a simple tubular structure heretofore described, but that it has normally two lateral buds or appendiceal structures which have escaped observation. Since the arrest in development occurred before the disappearance of the postanal gut, this structure is retained and develops as part of the alimentary tract, and the appendiceal structures peculiar to it also take on a growth of their own. In Figure 22 are shown the various types of postanal gut, and it is seen that considerable variation exists. One finds variations from the cases of simple tubular postanal gut with no appendixes to the case described here, in which the appendixes assume a marked prominence and the postanal gut is a mere shallow pouch. These variations may be simply explained by assuming that the cloaca has absorbed the postanal gut to a greater or lesser extent, just as it normally absorbs the adjacent part of the mesonephric duct,

22. Keibel does not consider this normal development.

or as the left atrium absorbs the pulmonary veins. In our case, the absorption occurred to such an extent that the postanal gut was almost entirely absorbed and the appendixes assumed separate openings, just as the ureter and vas normally assume separate openings by the absorption of the mesonephric duct. Objection to such an assumption may be made by pointing to the common duct for the vas and ureter in these specimens and claiming that, if the postanal gut had undergone absorption, the same should be true of the mesonephric duct. This objection is not a serious one, however, when one considers that the degree of absorption of these structures by the cloaca may vary in different areas, and further that the very presence of the postanal gut is evidence that absorption has not been complete in this structure. This explanation seems more logical than Wood-Jones's [1] assumption that this structure represents the large intestine with paired cecums,

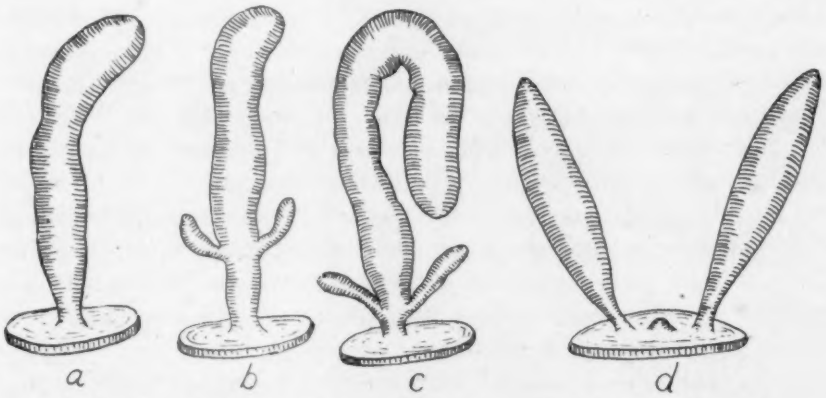

Fig. 22.—Types of postanal gut recorded: *a*, case of T. B. Johnston; *b*, case of Sequeira; *c*, case of Wood-Jones; *d*, author's case.

which he claims indicates that these malformed fetuses present a reptilian character. This reptilian character, he asserts, is shown by the presence of the common duct for the vas deferens and ureter; but my assumption of arrested development offers a simple explanation for the entire series of malformations.

Sequeira [5] believed that the postanal gut represents the entire large intestine, with a rectum which ends blindly, and that one of the appendixes is the cecum and the other the vermiform appendix. The cloaca he believed to be the vitelline duct. The impossible position of this so-called vitelline duct, however, is sufficient objection to discard such a nomenclature.

The absence of the anus in the specimen here described and in most of the others may be ascribed either to arrest in development or to the dependence of its development on the normal development of the other

organs. (Compare His's [23] "Unsere Körperform," "Die Entwickelung der menschlichen und tierischen Physiognomien" and "Das Prinzip der organbildenden Keimbezirke und die Verwandschaften der Gewebe.")

The formation of the tonguelike penis offers most interesting speculation. Its appearance is characteristic not only of these complicated exstrophies of the bladder (ectopia cloacae), but also of many of the simple types.

Coleman and Wilkinson [24] have described a case of this latter type, and the photographs are especially illuminating. Before offering an explanation for the formation of this organ, it becomes necessary to review the normal development of the external male genitalia and also the probable course in these cases in which separation of the midline structure of the body occurs.

The external genitalia, of 3 mm. greatest length, make their first appearance as paired swellings in embryos. They soon coalesce and form a single tubercle situated between the umbilical cord and the coccygeal tubercle and between the hind limb buds. This swelling is called the cloacal tubercle and is an outpouching of the cloacal membrane, or, more properly at this time, the urogenital membrane. It has four slopes; namely, an umbilical, an anal and two lateral slopes, and its cavity is a continuation of the urogenital sinus.

In embryos of 11 mm. greatest length, the cloacal tubercle undergoes differentiation in that the summit and the entire anal and part of the lateral slopes form a disklike structure called the phallus, and the remaining crescentic portion, made up of the umbilical slope and lateral slopes, forms the genital tubercle.

The phallus soon enlarges, elongates and undergoes further differentiation. On sagittal section, there is a broad hollow space, known as the pars phallica of the urogenital sinus, which communicates with the vesico-urethral anlage of the urogenital sinus. As the phallus enlarges, it becomes compressed laterally, so that its lumen becomes more or less slitlike along the anal surface and solid at the apex. This solid apical portion is destined to become the glans, and by the compression of the sides, the walls of this portion of the pars phallica urogenitalis become fused and form the solid urethral plate. A sulcus (coronary sulcus) is also formed, which further differentiates this glandar portion from the rest of the phallus.

Along the anal slope of the phallus, a medium slit appears, due to resorption, which extends into the pars phallica urogenitalis and forms

23. His, W.: Unsere Körperform und das physiologische Problem ihrer Entstehung, Leipzig, 1874.

24. Coleman, C. C., and Wilkinson, R. J.: Exstrophy of the Bladder, Surg. Gynec. & Obst. **26**:679 (June) 1918.

a communication with the outside. This slitlike opening is the ostium urogenitale. It extends along the entire length of the anal slope of the phallus to the coronary sulcus. Beyond the coronary sulcus is a wide shallow groove which has at its base the urethral plate. It extends from the coronary sulcus to the apex of the glans. In the male organ, up to this period of development, the ostium urogenitale is narrower at its anal portion than toward the glandular portion of the shaft of the penis. From this point onward, this portion of the organ undergoes comparatively little further development except growth in size, and its rôle is a passive one. As the rest of the shaft is pushed out from the basal tissues, this part is simply carried ahead.

Since the pars phallica urogenitalis also remains passive with the rest of the organ, it is evident that growth in length must be brought about by an active zone. This area is the pars pelvina urogenitalis. Active growth elongates the organ and pushes the already formed penis ahead, causing a lengthening of the ostium urogenitale so that it extends along the entire length of the shaft.

While these changes are occurring in the phallus, the genital tubercle enlarges and extends caudally, forming the lateral genital swellings.

According to Herzog,[25] a second development occurs, which is designated as the unpaired scrotal area. This area is situated immediately caudal to the ostium urogenitale; and as it enlarges, it fuses with the genital swellings, which gradually move caudally and are taken up by the former. The unpaired scrotal area, then, is the principal factor in the formation of the scrotum, and the genital swellings play a minor rôle and are absorbed. The medial connective tissue just beneath the unpaired scrotal area is thick and firmly attached, and as the scrotum is formed, this medial connective tissue becomes attenuated and forms a fibrous septum between the two halves of the scrotum. The connective tissue is represented by a depression on the external surface. When the descent of the testes is complete, these organs lie in the scrotum and are separated by this fibrous septum.

Although the scrotum may be formed as Herzog [25] has said, by a second developmental area, and the genital swellings may play an insignificant rôle, it is at least questionable whether this zone is an unpaired one. In my specimen, the scrotum is divided, and the halves are separated a considerable distance by skin which has none of the corrugated appearance of scrotal tissue. It would seem more likely that a paired scrotal area exists close to the median line and that each side develops independently.

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25. Herzog, F.: Beiträge zur Entwicklungsgeschichte und Histologie der männlichen Harnröhre, Arch. f. mikr. Anat. u. Entwcklngsgesch., Leipzig **63**:710, 1904.

The glans, as has been described, has a shallow furrow extending from the coronary sulcus to the apex, the floor of which is the urethral plate, formed from the fused sides of the pars phallica of the urogenital sinus. The edges of the urethral plate grow mesiad, and fuse and form a tube with an opening at the apex; while at its other end, it empties into the groove of the shaft.

The ostium urogenitale closes up from the anal edge upward, the endothelial lining of the pars phallica closing separately and the edges of the skin fusing. This latter fusion extends to the summit of the glans.

The prepuce is formed from the glands by a solid cylinder of epithelium, the glandar lamella, unclosed on the anal surface, which grows from the coronal suture to the apex. This solid cylinder forces its way under the surface epithelium and reaches the surface at the apex. Its central cells then undergo degeneration so that it breaks through at the apex; the remaining outer coat of cells forms the inner epithelial lining of the prepuce, and the epithelial lining of the primitive glans becomes the outer epithelial lining of the prepuce. The inner layer of the glandar lamella forms the epithelial lining of the glans. The unclosed portion of the glandar lamella forms the frenum and is the only remaining portion of the primitive glans.

The corpora cavernosa appear as condensations of the mesenchyme, which later assume their spongy characteristic appearance. The first to appear are the two corpora cavernosa penis; next the corpus cavernosum glandis, and last the corpus cavernosum urethrae. The two corpora cavernosa penis are united at the distal extremity and along the anal surface.

It is quite evident that, in the case here presented and in the others which have been described, the ostium urogenitale is formed on the umbilical slope or above the cloacal tubercle instead of on its caudal slope. Why this should occur is not evident; but that it does so is certain. The cleft then opens into the cloaca, and the pars phallica urogenitalis does not develop.

As the broad phallus develops and elongates, it carries with it on its umbilical surface the adjacent ostium, which forms a broad shallow groove. The epithelial lining is therefore derived from the entoderm, since it is a continuation of the cloacal epithelium. The caudal surface of the growing phallus is derived from the adjacent ectoderm and consequently cannot later be distinguished from the normal skin.

Since the troughlike groove lies on the umbilical surface of the phallus, it must necessarily lie above the corpora cavernosa. These structures as shown in Figure 17 are widely separated, and the corpus

cavernosum urethrae lies between them. This is evidently due to the broadening of the entire fetus as evidenced by the separation of the other midline structures.

It is evident that the umbilical surface of the deformed penis represents the misplaced and open pars phallica of the urogenital sinus, and the median bar which extends from its base to the junction of the lateral masses represents the pars pelvina urogenitalis.

As has been previously stated, the scrotal halves are separated and are developed independentaly from anlagen on either side of the midline. Whether these anlagen are the genital swellings, or whether secondary anlagen develop which absorb the genital swellings, cannot be stated.

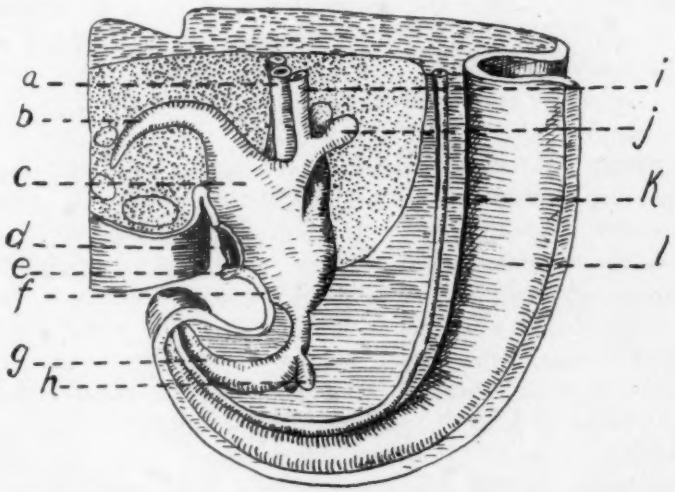

Fig. 23.—Modified reconstruction of the hind end of an embryo, 6.5 mm. long (original from Keibel): *a*, small intestine; *b*, allantois; *c*, cloaca; *d*, rupture of cloacal plate over the cloacal tubercle; *g*, postanal gut; *h*, diverticulum of postanal gut; *i*, mesonephric duct; *j*, metanephric anlage; *k*, notochord; *l*, neural groove.

Figure 23 is a modified illustration from Keibel. The supposedly existing appendixes of the postanal gut have been added, and the cloacal membrane has been removed to represent the area of cleavage. The cloacal tubercle has been added to illustrate the formation of the malformed penis. This modified illustration presents, in a general way, the conditions found in complicated exstrophies of the bladder (ectopia cloacae). It is entirely unnecessary to assume the retention of a misplaced vitelline duct or the presence of a rectum; for if these malformations are the result of a retention of the normal early embryonal structures, no further elaboration except the evident separation of the lateral plates is necessary.

Simple exstrophy of the bladder (ectopia vesicae) represents a further differentiation of the embryonal structures, with cleavage of the cloacal membrane above the cloacal tubercle. In some of these cases, cleavage may also occur below the cloacal tubercle, and a urethra may be formed; but there is always an epispadias. Wood-Jones [1] believes that these simple exstrophies are due to an abnormal cleavage of the cloacal membrane at a later period of embryonal development, and that epispadias alone represents a still later cleavage.

This explanation, at first glance, seems an adequate one; but it is difficult to perceive how epispadias, limited to the shaft of the penis, would take place under these circumstances. One would be forced to conclude that a cleft occurred on the umbilical surface of the elongated phallus. Since the umbilical wall of the growing phallus is comparatively thick, owing to the formation of the urethral plate, it is hardly likely that a cleft would develop in this region during its growth. It seems more reasonable to suppose that all of the malformations, from the grave types to simple epispadias, are produced at approximately the same time but are affected to a different degree by the underlying inciting cause. In Hertwig's [19] experiments, spina bifida did not occur when the eggs were subjected to 0.5 per cent. sodium chlorid solution; while at 0.6 per cent., only about half developed a spina bifida and at 0.7 per cent., all of them were affected. In other words, the embryos were not affected alike. Is it not likely that a chemical substance in the uterine mucosa might act in the same manner and cause only a slight arrest in some embryos, whereas it would cause a marked arrest in others? Such a difference might be accounted for either by the strength of the chemical substance or by the resistance of the embryo. If this chemical substance is of comparatively high concentration and the delay in development correspondingly great, its effect would be shown by a marked separation of the medial edges of the lateral plates, a long line of cleavage of the cloacal membrane above the cloacal tubercle, spina bifida, and a failure of the cloaca to separate into the urogenital sinus and large intestine. In somewhat lesser concentration, this substance would bring about a shorter delay, effecting the developing embryo to a lesser degree. Here, then, the lateral plates would be less widely separated, and the median cleft above the cloacal tubercle would be correspondingly shorter. This theory assumes that the less concentrated the chemical substance, the less would the embryonal development be delayed and the less the tendency to retention of the embryonal structures. It would assume that the arrest, no matter of what degree, occurs at approximately the same period of embryonal development.

Such an assumption would offer a simple explanation for epispadias confined to the shaft of the penis; for if a short cleft developed during

early embryonal development, either on the umbilical surface of the cloacal tubercle or immediately above it, this cleft would be carried along the umbilical surface of the growing phallus after its differentiation and elongation. As the ostium primitivum along the caudal surface of the cloacal tubercle occurs as in normal development, the pars phallica urogenitalis communicates with the outside on both its caudal and its umbilical surface. This means that the body of the phallus consists of two separate halves which join at the base and at the extremity.

A longer cleft would extend into the pars pelvina of the urogenital sinus, and consequently, after development, the resulting epispadias would extend into the prostatic portion of the urethra.

TUMORS OF THE EPIDIDYMIS, SPERMATIC CORD AND TESTICULAR TUNICS

A REVIEW OF THE LITERATURE AND REPORT OF THREE NEW CASES *

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Tumors of the testicle are relatively rare, constituting 5.8 per thousand (0.58 per cent.) of all malignant tumors in men (census statistics on the mortality of cancer in the registration area of the U. S.[1]). Nevertheless, they have received a great deal of attention in the literature, both in this country and abroad, and are still a subject for controversy from the clinical as well as the pathologic standpoint. The conclusion has gradually evolved that for practical purposes all tumors of the testicle are malignant (Ewing) and that tumors, either benign or malignant, arising in the adjacent structure (epididymis, cord and tunics) are so rare as scarcely to deserve mention.

The occurrence in our experience during the last four years of one case of pure fibroma of the cord and two very unusual epithelial neoplasms of the epididymis has prompted us to make a rather exhaustive survey of the literature, and to report these three cases, not only because of the extreme rarity of extratesticular scrotal tumors, but also because the subject as a whole has received such scant attention, especially in this country.

Since no one has attempted a systematic classification of this group of tumors, an outline of our paper is submitted, with the hope that it may lead to a clearer understanding of the subject. Only the solid tumors of this region are recorded, cysts of the epididymis [2] and cord, hydro-

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1. For full discussion of testicular tumors, see chapter on "Tumors of the Testicle," in Cabot's Modern Urology, Ed. 2, at the present writing still on the press.

2. Cysts of the epididymis and surrounding structures have been the subject of a voluminous foreign literature, but, as Wolbarst states, judging from the most recent American urologic literature, they are either too common to mention, or so rare that authors consider it unnecessary to refer to them. Textbooks on urology, with the exception of Keyes' (1910), do not mention them. Henry Morris described the condition fully in 1898. The condition is probably common enough, but is incorrectly diagnosed as hydrocele of the cord or tunica vaginalis, or not recognized. Wolbarst distinguishes two varieties: (1) multiple small cysts in the epididymis like currants in size and shape, occasionally containing spermatozoa, in which case the fluid is thicker and more opalescent, and (2) large cysts, generally containing sperm, and which if multiple may cause separation of the testicle from the epididymis.

celes, granulomas, etc., not being included. Tumors of the spermatic cord constitute probably in the neighborhood of 90 per cent. of the group of extratesticular scrotal tumors, and most of the literature, which is principally foreign, is devoted to them. They are therefore given first consideration in the following classification:

I. Tumors of the Spermatic Cord:
  A. Benign:
    1. Epithelial (none recorded).
    2. Mesoblastic:
      (a) Lipoma.
      (b) Fibroma.
      (c) Myxoma.
      (d) Leiomyoma.
      (e) Vascular tumors (lymphangioma).
    3. Heterologous tumors:
      (a) Cystic dermoid.
  B. Malignant:
    1. Epithelial (no authentic case).
    2. Mesoblastic:
      (a) Sarcoma (myxosarcoma, chondrosarcoma, fibrosarcoma, spindle-cell, etc.)
    3. Heterologous tumors:
      (a) Teratoma (including seminoma of Chevassu).
II. Tumors of the Epididymis:
  A. Benign:
    1. Epithelial (none recorded).
    2. Mesoblastic:
      (a) Lipoma.
      (b) Fibroma.
      (c) Myxoma.
      (d) Leiomyoma.
    3. Heterologous tumors:
      (a) Cystic dermoid (none recorded).
  B. Malignant:
    1. Epithelial:
      (a) Carcinoma.
    2. Mesoblastic:
      (a) Sarcoma (lymphosarcoma, chondrosarcoma, melanosarcoma, spindle-cell, etc.).
    3. Heterologous tumors:
      (a) Teratoma (including seminoma of Chevassu).
III. Tumors of the Testicular Tunics:
    1. *Tunica Vaginalis:*
  A. Benign:
    1. Epithelial:
      (a) Adenoma.
    2. Mesoblastic:
      (a) Lipoma.
      (b) Fibroma.
    3. Heterologous tumors:
      (a) Cystic dermoid (none recorded).
      (b) Rhabdomyoma.

B. Malignant:
1. Epithelial:
(a) Carcinoma (none authentic).
2. Mesoblastic:
(a) Sarcoma.
3. Heterologous tumors (none reported).
2. *Tunica Albuginea:*
(a) Fibroma.
(b) Sarcoma.

TUMORS OF THE SPERMATIC CORD

Historical Note.—Cloquet [3] (1819) recorded the earliest known cord tumor, a lipoma which, according to Patel and Chalier,[4] originated from a fat hernia, and was therefore not a true cord tumor. In 1845, Lésauvage [5] reported in his memoirs on albuminogelatinous tumors three cases, two of myxomatous nature, and one malignant of uncertain character, arising from the cord and independent of the testicle. A gummatous tumor was reported in 1856 by Lhonneur, and in the same year a fibroma of the cord by Fergusson.[6] The rapidity of recurrence in the latter case suggests that the tumor had undergone sarcomatous degeneration. Curling,[7] in 1857, dedicated a chapter to fatty tumors of the cord, reviewing previous reports, and remarking on a unique case of recurring lipoma of the cord. Poisson [8] (1858) records, in his thesis on fibrous perididymal tumors, a case which may be considered a cord tumor (Brossard [9]) since it developed from the terminal part of the vas deferens and invaded the tail of the epididymis. Verneuil,[10] in 1864, presented to the Société de Chirurgie a fibroplastic tumor of the spermatic cord, and, in 1865, Louvet [11] presented a similar neoplasm, "sarcome fibróide," developing in the region of the tail of the epididymis, and first part of the cord of a child of 7 years. Bryant,[12] in 1875, described a medullary sarcoma of the cord in a young man of 19 years,

3. Cloquet: Tumeur graisseuse développée dans le cordon testiculaire et trouvée sur le cadavre d'un vieillard, Thèse de concours, Paris, 1819.

4. Patel and Chalier: Tumeurs du cordon spermatique, Rev. de chir., 1909, pp. 119, 354, 603, 792, 942.

5. Lésauvage: Tumeur albumino-gélatineuse du cordon, Arch. gén. de méd. **9,** 1845.

6. Fergusson: Fibrous Tumor of the Scrotum Enveloping the Left Testicle and Distending the Inguinal Canal, Lancet **2**:11, 1856.

7. Curling: On Diseases of the Testis, 1857, 1878.

8. Poisson: Tumeurs fibreuses péridídymaires, Thèsis (Paris), 1858, No. 12.

9. Brossard: Des tumeurs solides du cordon spermatique, Arch. gén. de méd., Paris **2**:267-308, 1884.

10. Verneuil: Gaz. des hôp., 1859.

11. Louvet: Tumeur fibroplastique péridídymaire, Bull. soc. anat. de Paris **40**:508, 1865.

12. Bryant: Sarcoma of the Spermatic Cord, Lancet, 1875.

ending fatally. Tizzoni and Parona,[13] in 1877, reported a case of tetanus following excision of a fibrolipoma of the cord in a patient of 45 years, and Walsham,[14] in the course of the year 1880, described three cord tumors, one a myxosarcoma in a 13 months old infant; another a tumor of tubular structure intimately bound to the epididymis in a child of 4 years, and a third a "mixed sarcoma" in a 5 months old infant. Other isolated cases were reported, and in 1884, Brossard's [9] excellent review of the literature on solid tumors of the spermatic cord appeared. He collected nineteen cases and classified the tumors as follows: benign: lipomas (three), myxomas (one); fibromas (four); fibrolipomas (one); gummas (one); malignant: sarcomas (two), carcinomas (two), and four growths of uncertain character. They were all primary cord tumors except one reported as carcinoma, which originated in the testicle. The remaining tumor reported as carcinoma was not examined microscopically, and therefore cannot be accepted. In 1885, Eben Watson [15] published a work on benign tumors of the cord and their differentiation from hernia. Alombert-Goget [16] (1887) extended Brossard's observations and collected twenty-five cases of solid tumors of the cord, which were classified as follows: Seven lipomas, three fibromas, one myxoma, nine sarcomas, four cancerous tumors and one unclassified tumor. In 1888, the pathogenesis of lipomas of the cord was completely presented before the Société Anatomie de Paris by Broca and Delbet. The subject was further elaborated by Sarazin [17] in 1895, who collected twenty-six observations of lipomas of the cord. Deroyer [18] (1897) and Gabryzewski [19] (1898) further elaborated the subject, and finally, in 1910, Beresnegowsky [20] collected thirty-three authentic cases of lipomas of the cord, with a complete bibliography. Tumors of the cord in general

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13. Tizzoni and Parona: Sopra un caso di fibrolipoma del cordone spermatico, Ann. Univ. di Med. e Chir. **239**:193-208, 1877.

14. Walsham: Myxo-Sarcoma of the Spermatic Cord Removed from a Child Thirteen Months Old, Tr. Path. Soc., London **31**:299-302, 1879-1880.

15. Watson, Eben: On the Nonmalignant Tumors of the Spermatic Cord, and Their Diagnosis from Hernia, Lancet **1**:792, 837, 1885.

16. Alombert-Goget: Des tumeurs solides du testicule, Thèse de Lyon, 1887, No. 387.

17. Sarazin: Contribution à l'étude des lipomes du cordon spermatique, Thèse de Paris, 1895, No. 513.

18. Deroyer: Des tumeurs solides du cordon spermatique, Thèse de Paris, 1879, No. 349.

19. Gabryzewski: Des lipomes du cordon spermatique, Deutsch. Ztschr. f. Chir. **47**, 1898.

20. Beresnegowsky: Zur Kenntnis der Lipome des Samenstranges, Beitr. zur. Klin. Chir., Sept. 3, 1910, p. 749.

have been dwelt on in the contributions of Patel and Chalier [4] (1909), Darbeau [21] (1919) and others, while Tédénat and Martin [22] (1908) devoted a paper to sarcomas of the cord.

The relative frequency of cord tumors is best illustrated by the statistics of Patel and Chalier,[4] who collected eighty-nine cases: lipomas, thirty-seven; sarcomas, twenty-two; mixed tumors, thirteen; fibromas, twelve; myomas, four; carcinomas, one.

Lipoma.—True lipoma of the cord is rare, but is nevertheless the most common cord tumor. The most notable contributions on this group of tumors are those of Watson [15] (1885), Hutchinson [23] (1886), Sarazin [17] (1895), Sitzenfrey [24] (1898), Gabryzewski [19] (1898), Malgaigne [25] (1909), Patel and Chalier [4] (1909), Beresnegowsky [20] (1910), Chalier [26] (1910), and Schiller [27] (1918).

Hutchinson [23] reviewed twenty-three cases (twenty inguinal and three femoral), of lipomas in femoral regions, and noted that eighteen occurred on the left side and five on the right. In the dissection of twenty-two cadavers, he found that, in eleven cases, no fat was grossly demonstrable in the cord; in six there were a few small lobules, and in four there were small out-growths at the upper extremity of the cord, which had apparently come through the inguinal canal. He attributed the origin of lipomas in the femoral region to fat just outside the peritoneum, and noted that they occurred in both spare and fat subjects, and often seemed to depend on local fat hypertrophy.

In a study of fifty cadavers, Gabryzewski [19] always found more or less fat, lying in the perivascular tissue along the cord to the epididymis, and, in the region of the inguinal canal, connected with subperitoneal fat.

Schiller [27] states that lipomas in the inguinal canal are common, and that Kellogg Speed, in 154 operations for hernia, found seventy-five lipomatous growths which had their origin in properitoneal fat. He says further that they apparently arise from subserous fat about the internal ring, singly or severally; grow along the canal distending it, and often follow the cord as far as the scrotum. They vary in size

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21. Darbeau: A l'étude des tumeurs du cordon spermatique, Thèsis (Bordeaux), 1919, No. 23.

22. Tédénat and Martin: Tumeurs malignes du cordon spermatique, Arch. gén. de chir., 1908, p. 113.

23. Hutchinson, Jonathan, Jr.: Lipomata in Hernial Regions, Tr. Path. Soc., London **37**:451, 1886.

24. Sitzenfrey: Beitrag zur Lehre von den Lipomen des Samenstranges, Beitr. z. Klin. Chir. **22**:386-391, 1898.

25. Malgaigne: Tumeurs du cordon spermatique, Lyon méd., Dec. 5, 1909.

26. Chalier: Lipomes du cordon spermatique, Lyon méd., Dec. 5, 1909; Ann. d. mal. d. org. génito-urin. **2**, 1910.

27. Schiller: Lipoma of the Funiculus Spermaticus, Ann. Surg. **68**:269 (Sept.) 1918.

up to many pounds, and have at times a distinct peritoneal capsule. They are in many instances a predisposing cause of hernia, not only because they distend the internal and external rings and the inguinal canal, but they will, by propulsion, produce an infundibulum in the peritoneum, and thus a hernial sac, as is frequently exemplified by the fatty hernia, which may contain a small peritoneal sac in the midst of thick masses of fat.

Schiller [27] comments on the rarity of true lipoma of the cord, and states that its origin lies in the small fat lobules within the tunica vaginalis communis of the cord. They may extend upward and end abruptly in the inguinal canal or become fused with properitoneal fat, and distally may extend to the testis and epididymis. Occasionally, the tumor may break through the tunica vaginalis communis and become connected with subcutaneous fat, thus disguising its true origin. The pathologico-anatomic differential diagnosis between true lipoma of the cord and the common lipoma arising from properitoneal fat is simple at an early stage, but later may be difficult. Ordinarily, a lipoma of the cord is surrounded by the tunica vaginalis communis and derives its blood supply from the vessels of the cord; while the lipoma from properitoneal fat should show connections with this layer; derive its vascular supply from the same source, and lie outside the tunica vaginalis communis. If, in time, the cord lipoma breaks through the tunica vaginalis communis, it is difficult to differentiate. Clinically, there are, depending on the size and location of the tumor, all the symptoms of hernia: a soft tumor in the inguinal canal, which may show impulse on coughing and enlargement in the erect position, and may be replaced in the abdomen in some cases. If the growth is well down in the scrotum, it may be mistaken for hydrocele, cyst, testicular tumor, etc. The treatment is the same in any case, and it is well for the surgeon to remember that lipomas of the inguinal canal often contain a peritoneal sac, and that there may exist a large fat hernia with a small sac containing a viscus.

Fibroma.—Fibromas of the cord are about one third as frequent in occurrence as lipomas. Patel and Chalier [4] (1909) were able to collect but twelve cases in the literature. The earliest observation found is that of Lenoir [28] (1844-5). In 1851, von Haelst [29] described a scirrhous cord tumor, the nature of which is not very clear. Other cases in chronological order are: Fergusson [6] (1856), Poisson [8] (1858),

28. Lenoir: Tumeur fibreuse du cordon, Bull. soc. de chir. de Paris **5**:344, 1844-1845.

29. Von Haelst: Extirpation d'une tumeur squirrheuse du cordon testiculaire, Arch. belges de méd. mil., Bruxelles **8**:302-4, 1851.

Létiévant [30] (1864), Morel-Lavallée [31] (1864), Tizzoni and Parona [13] (1877), Eben Watson [15] (1885), Audry [32] (1887), Monod [33] (1903), Bruno, Condo and Satriano [34] (1904), Delassus [35] (1906-1907), Dubar and Leroy [36] (1908), Villard and Rhenter [37] (1908). In the cases of Létiévant,[30] Tizzoni and Parona,[13] and Eben Watson,[15] the tumors are called fibrolipomas, but are essentially fibroid in character. Fergusson's [6] patient had a recurrence ten months after operation, and the growth had probably undergone sarcomatous change. The case of Villard and Rhenter [37] was unique in that the tumor weighed 15 kg. Although fibromas are usually small, the tumor in the case of Bruno et al.[34] weighed 190 gm., that of Delassus,[35] 370 gm. and that of Audry,[32] 1,125 gm. Later reports of value are those of Riche and Jourdan [38] (three cases), Vecchi [39] and Opokine.[40]

In general, the origin for these tumors appears to be in the caudad portion of the cord near its junction with the epididymis, from the connective tissue uniting the various elements of the cord (Patel and Chalier [4]). This fact explains the confusion in the literature as to the exact origin of certain tumors and throws light on the expressions, "peridídymal tumors" (Poisson,[8] Louvet [11]), and "fibroma of the tail of the epididymus" (Audry,[32] Poncet [41]). In the cases of Delassus,[35] and of Dubar and Leroy,[36] the origin was apparently at the level of the inguinal canal. These tumors are usually of firm consistency, smooth and encapsulated, resembling a fibroid of the uterus. They are often mistaken for hydrocele. The tunica vaginalis is sometimes distended

30. Létiévant: Tumeur fibro-graisseuse du cordon; énucléation; gangrène; mort, Mem. et compt.-rend. Soc. de sc. méd. de Lyon **3**:124, 1864.

31. Morel-Lavellée: Fibrome du scrotum, Bull. soc. Chir., Paris, 1864, p. 192.

32. Audry: Fibrome énorme de la queue de l'épididyme droit, Gaz. d. hôp., 1887, p. 479.

33. Monod: Fibrome du cordon, Bull. et mem. soc. de chir. de Paris **29**:1039, 1903.

34. Bruno, Condo and Satriano: Des fibromes du cordon spermatique, Rev. de chir. **29**:105-113, 1904.

35. Delassus: Fibrome du cordon, Castration, Thèse de Dubois, Lille, 1906-1907, p. 25.

36. Dubar and Leroy: Apropos d'un fibrome du cordon spermatique, Echo méd. du nord., Lille **12**:25-30, 1908.

37. Villard and Rhenter: Enorme fibrome du cordon spermatique, Lyon méd. **2**:1386, 1908.

38. Riche and Jourdan: Volumineuz fibrome du cordon, Montpellier méd., 1912, p. 352, and Feb. 24, 1911.

39. Vecchi: Fibroma d. Funicolo Spermatico, Gaz. med. ital., June 29, 1911.

40. Opokine: Fibrome du cordon spermatique, Chirurgia, No. 177, September, 1911.

41. Poncet: Fibrome énorme de la queue d' épididyme droit, Gaz. d. hôp. **1**:285-290, 1887.

with fluid. As regards age in the twelve cases above mentioned, nine occurred between 45 and 57 years, one at 18, one at 32 and 1 at 67. Trauma is mentioned as a factor in but one case. The growths are painless and slow growing. The patient generally mistakes the condition for hernia, which is occasionally present also. In eight cases, the duration was ten, ten, six, six, from six to seven, four and two years, and six months. The tumor may sometimes be reduced into the abdomen, and transmit an impulse on coughing, and may even transmit light, as in our own case. There appears to be a certain tendency to

Fig. 1 (Case 1).—Fibroma of spermatic cord, sectioned through middle and opened: *A*, central corelike nodule. The tumor presents a picture of unusually dense, solid fibrous tissue.

sarcomatous degeneration in this group (Fergusson's [6] case), judging from the clinical course of many of the sarcomas of this region.

Report of an illustrative case is subjoined.

Case 1.—*History.*—J. C., had a mass in the left side of the scrotum and enlarged veins in the left leg. He had had measles in childhood; pleurisy three years previously, and gonorrhea twice (six years and two years previously). There was a swelling of the right testis with first infection. No history of syphilis was elicited. One sister and one brother had died of

pulmonary tuberculosis at the ages of 26 and 28, respectively. About five years previously the patient first noticed a small hard mass in the scrotum just above the left testicle, about the size of a marble. It was not tender or painful. He paid no further attention to it until three years previously when he was rejected by the army as having a spermatocele. In the meantime, the tumor had grown somewhat, but was still hard and firm, and caused an occasional dragging pain in the left groin. During the last two years, it had remained about the same size.

Physical Examination.—About 2.5 cm. above the left testicle a rough, oval, firm, slightly nodular mass, a little larger than the testicle, was felt. The vas deferens was apparently not connected with the mass except along its internal aspect. The mass seemed intimately connected with the outer coverings of the cord. The patient had large tortuous veins in the popliteal space and crural region on the left side, of eight years' duration and growing worse.

Operation.—Jan. 12, 1920, under local anesthesia, the skin was incised over the tumor, which was well encapsulated and freely movable; and it was easily enucleated. The spermatic cord coursed over its posterolateral aspect. The tumor appeared to have its origin from the tunica enveloping the cord. Recovery was uneventful.

Pathologist's Report.—The specimen consisted of a slightly bosselated tumor (Fig. 1), measuring about 4 cm. across, and covered by a very firm capsule of slight vascularity. The cut surface of the tumor showed one good sized very hard spherical mass about 1 cm. across, embedded in a fairly uniform, very elastic, somewhat spongy background of whitish gray. One could see, between the white strands of connective tissue, fibrils running at right angles to the general structure, or collections of cells of some undifferentiated type. The surface was somewhat glaring, but had not the shiny glistening character which is usually seen in myxomas, and there was none of the bluish tinge of cartilage. In the center could be distinguished a corelike nodule about 1 cm. across (Fig. 1 *A*).

Microscopic Examination.—A section from the main tumor near the edge, (Figs. 2 and 3) showed fibrous tissue, of the adult type, arranged in a very compact manner in whorls and bands. The fibrils predominated over the nuclei. Blood vessels were extremely numerous, small and thick walled. The majority had walls twice as thick as the diameter of the lumen. Throughout, there was infiltration with small lymphocytes and plasma cells. A section of the nodule (Figs. 4 and 5) showed a less degree of vascularity, and the vessels were not so thick walled. The infiltration of inflammatory elements is much more marked, and in addition polymorphonuclear cells were frequently seen. Both sections showed hyalin changes.

The picture was that of a rather vascular connective tissue tumor of benign type, in which there was, for some reason, considerable chronic inflammatory reaction.

Myxoma.—This is an extremely rare type of cord tumor. Mayer [42] (1919) reported a case of myxofibroma of the cord, and could find but two other cases of like nature (Schlueter, Goodhart). Brossard [9] (1884)

42. Mayer: Myxofibroma of the Spermatic Cord, Ztschr. f. Urol. **13**:1 (Jan.) 1919.

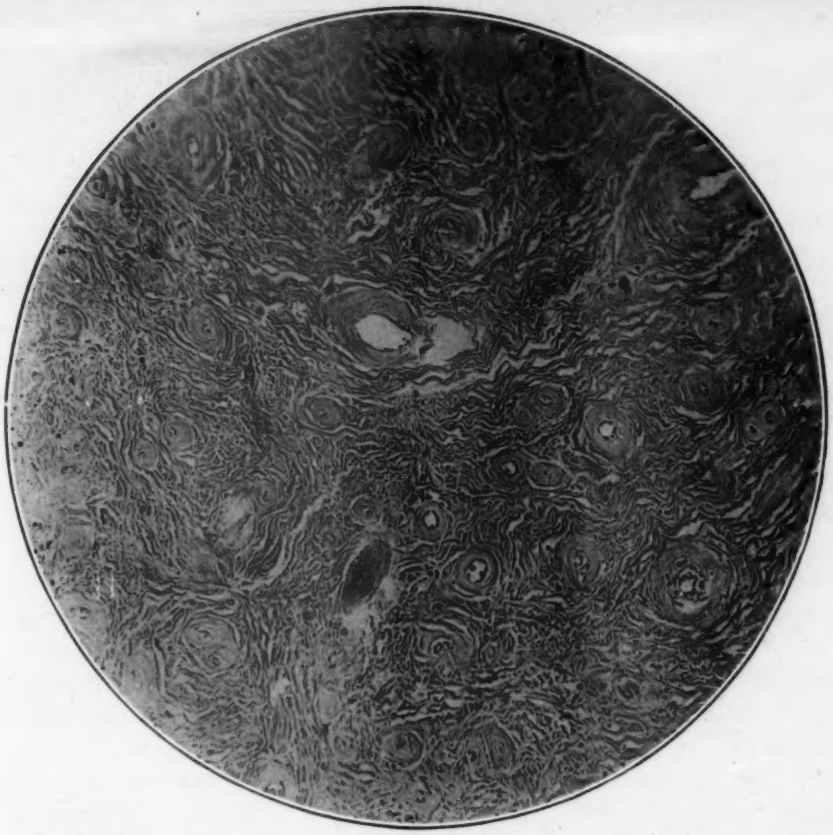

Fig. 2 (Case 1).—Low power microscopic view of area near edge of main tumor (Fig. 1). The extremely numerous thick-walled vessels may be noted.

Fig. 3 (Case 1).—High power microscopic view of area shown in Figure 2.

Fig. 4 (Case 1).—Low power microscopic view of central nodule from tumor (Fig. 1 *A*). The vessels are less numerous and there is more marked inflammatory infiltration.

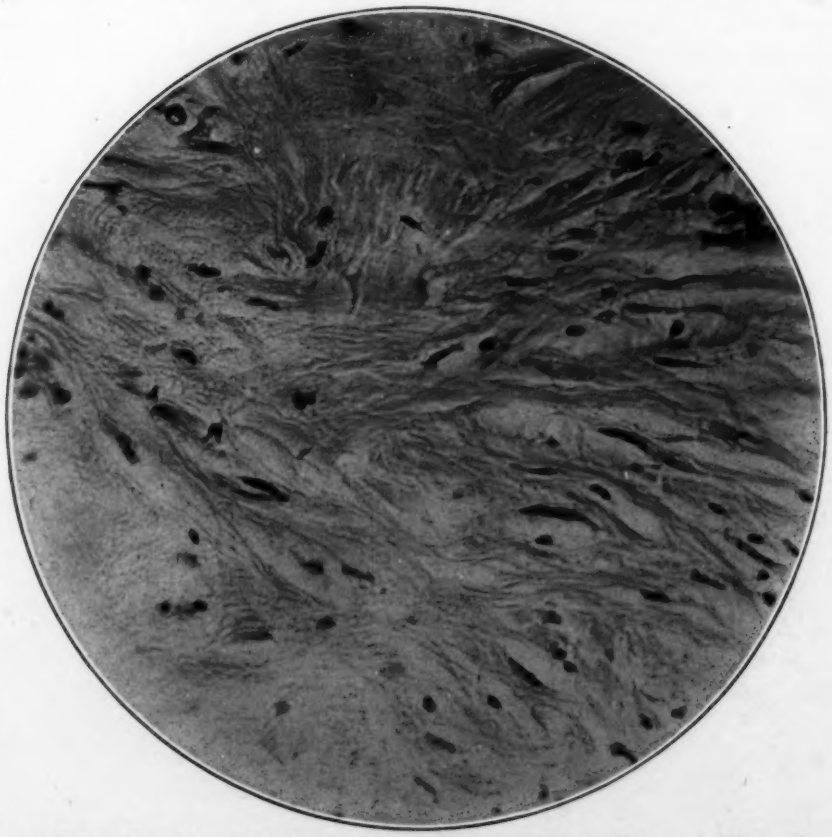

Fig. 5 (Case 1).—High power view of area shown in Figure 4, illustrating density of the connective tissue.

could find but two cases of pure myxomas in the literature (Observations 3 and 4 of Lésavauge,[5] to whom reference has been made). Pepper [43] described a case in 1885, which was of sarcomatous nature, and Cathelin and Beauvy [44] reported a juxta-testicular fibromyxoma in 1909. Gauthier [45] (1897) described a lipomyxoma of the cord, and Marnoch [46] (1899) reported in detail a lipomyxofibroma. Their clinical features are the same as those of fibromas of the cord, from which they probably arise in most cases.

Leiomyoma.—Brossard [9] (1884), in his review of the literature, makes no mention of myomas of the cord, yet such a case has been reported by Trélat [47] (1880), in an infant. Patel and Chalier [4] (1909) collected four cases, and reported a singular case of malignant leiomyoma of the cord in a boy of 15 years. The tumor was enucleated, but the patient died five months later of generalized metastases. They place in one group myomas of the epididymis and cord, because of the difficulty in determining their exact point of origin. They appear to arise in the region of the junction of the vas and epididymis (Portalier [48]), and are generally adherent to both. Schuessler,[49] in 1916, reported a myoma of the cord in a man of 52 years. The tumor, which weighed 62 gm., was removed from the funiculus above the testicle. He believes that, in most instances, these growths arise from the smooth muscle fibers of the cremasteric internus of the tunica vaginalis communis, and are independent of the epididymis and vas deferens. Portalier has contributed a comprehensive thesis on the subject of leiomyomas of the cord.

Vascular Tumors.—Tubby [50] (1900-1901) reported an angiomatous tumor extending along the spermatic cord. No other reports of this nature have been found.

Dermoid Cysts.—From the standpoint of origin, dermoid cysts of the spermatic cord are rather inexplicable to theorists, not only because

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43. Pepper: A Case of Myxo-Chondro-Sarcoma of the Spermatic Cord, Tr. Path. Soc., London **36**:297-299, 1884-1885; abstr. Brit. M. J. **1**:180, 1885 and Med. Times & Gaz., London **1**:128, 1885.

44. Cathelin et Beauvy: Fibro-myxome juxtatesticulaire, Bull. et mem. de la soc. anat. de Paris, June 18, 1909.

45. Gauthier: Lipomyxome du cordon spermatique, Echo méd. de Lyon **2**:91, 1897.

46. Marnoch: Tumor of the Spermatic Cord, Scot. M. & S. J. **5**:43-47, 1899.

47. Trélat: Myoma du cordon, J. de méd. et de chir. prat., 1880, pp. 259-261.

48. Portalier: Contribution à l'étude des leio-myomes du cordon spermatique, Thèse de Lyon, 1908.

49. Schuessler: Die Myome des Samenstranges, Deutsch. Ztschr. f. Chir. **135**:268-278, 1916.

50. Tubby: Angiomatous Tumor Extending up the Spermatic Cord, Rev. Soc. Study Dis. Child., London **1**:24-26, 1900-1901.

of their extreme rarity, but also, and especially, because their situation is unusual for tumors of this nature. Indeed, the few opinions expressed have little support in fact, and may be summarized by the theory that they arise from primitive ectodermal cells displaced in the embryo from the lumbar region through the Wolffian body, and accompany that organ as rests in its ultimate transition to the vas deferens (Meyer,[51] Guinard,[52] Wrede,[53] Monti [54]). In this location, they cannot *ipso facto* be considered sequestration dermoids, yet their simple structure conforms more to that of this type than to that of the more complex internal dermoids such as occur in the ovary. In the testicle and ovary, they have been attributed to parthenogenetic development of sex cells, but when they are remote from these organs, the embryonic cell rest or misplaced blastomere theory is more satisfying to the mind in the absence of proved facts.

The literature was carefully reviewed by Pozzo [55] in 1911, who found nineteen cases and added a personal case. Only two cases have been reported in this country (Waiss,[56] 1908; Fox,[57] 1916). These tumors are small, indolent, semi-fluctuant and cystic, and do not transmit light. In none of the cases reported have they been diagnosed clinically, prior to operation. They usually are situated in the inguinal region and diagnosed as hydrocele of the cord or hernia. They are of long duration, their presence generally having been noted since infancy. They are usually small, but may grow rapidly. These patients come to the surgeon most often in early adult life. The tumors are attached to the connective tissue about the cord and are easily shelled out. The structure is generally very simple. The inner wall of the cyst is lined by epidermis, usually with hair projecting, and it is filled with pultaceous matter.

MALIGNANT TUMORS OF THE SPERMATIC CORD

Epithelial Tumors.—No reports have been found of neoplastic proliferation of the epithelium of the vas deferens, either benign or malignant in character. Curling [7] cites the case of Hunter, and that of

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51. Meyer: Ueber Dermoidcysten im Lig. Latum, am Samenstrange und Nebenhoden, Virchows Arch. f. path. Anat. **168,** 1902.

52. Guinard and Cambéssedès: Kyste dermoide du trajet inguinal, Gaz. d. hôp., 1909, No. 22.

53. Wrede: Die Dermoide des Samenstranges, Beitr. z. klin. Chir. **48**:273-281, 1906.

54. Monti: Die Dermoide des Samenstranges, Wien. klin. Wchnschr. **27**: 1182, 1914.

55. Pozzo: Le cisti dermoidi del cordone spermatico, Atta. della R. Accad. dei Fisiocritici di Siena, 1911, Zentralbl. f. Chir., 1912, p. 340.

56. Waiss: Dermoids of the Inguinal Canal, Surg., Gynec. & Obst., 1908.

57. Fox: Dermoid Cyst of the Spermatic Cord, J. Michigan M. Soc. **15**:338 (July) 1916.

Spence of Edinburgh (1856), which are recorded as cancer. Bottini [58] (1869), Warren [59] (1883-1884), and Poisson [60] (1883), report cancerous tumors of the cord, but the reports are not authenticated and are devoid of detail.

One authentic instance exists of carcinoma of the spermatic cord, in which the origin was thought to be in remnants of the Wolffian body—the case of Tédénat and Vieu, accepted by Patel and Chalier,[4] and reported by Tédénat and Martin.[22] The patient, aged 42, had a negative venereal history. The tumor occupied the inguinal canal and upper part of the scrotum and projected within the internal ring. It was of about nine months' duration, painless and slow growing at first, but rapidly growing and painful the last three or four months. It was removed at operation and was found to extend the whole length of the cord, the latter being buried in the growth. The testicle and epididymis were normal. Microscopic examination revealed cuboidal cylindrical cells in alveolar arrangement as occurs in the Wolffian body. The epithelium of the vas was normal throughout. The patient died two and one half years after operation, with emaciation, ascites and abdominal pain.

Mesoblastic Tumors (Sarcoma).—Sarcomas are the most important group of cord tumors, not only because of their malignancy, but, if we may accept the reports in the literature, also because they form, next to lipomas, the most common cord tumor, and therefore deserve especial consideration.

Richter,[61] Fasano,[62] Celso,[63] and Tédénat and Martin [22] have made comprehensive studies of this group of tumors. Twenty-two of the eighty-nine tumors of the cord (24.7 per cent.) collected by Patel and Chalier [4] were sarcomatous. Tédénat and Martin,[22] in 1909, reported a case and abstracted twenty-four cases found in the literature. The earliest case which they record is a fibro-sarcoma reported by Fer-

58. Bottini: Cancro primitivo del cordone spermatico destro, complicato da voluminoso oscheocoele libero, ed idrocela della vaginale; remozione del neoplasma con porzione del sacco ernioso; guarigione completa, Ann. univ. di med., Milano **208**:89, 1869.

59. Warren: Encysted Cancer of the Spermatic Cord, Virginia M. Monthly **10**:224-226, 1883-1884.

60. Poisson: Tumeur du cordon spermatique récidivée; (carcinome), J. méd. de l'ouest, Nantes, **17**:310, 1883.

61. Richter: Zur Kasuistik der Sarkome der Samenstranghüllen, Inaug. Diss., Munich, 1902.

62. Fasano: Deux cas de sarcomes du cordon spermatique, La Policlinique, 1908, p. 489.

63. Celso: Contributo allo studio dei sarcomi primitive del funicolo spermatico, Gaz. d. osp., May 15, 1910.

gusson [6] (1856). They do not mention the case of Maylard [64] (1893-1895), in which true bone had developed within a sarcoma of the cord, or the case of Mason [65] (1883), in this country. The case of Lemarque [66] (1887), Lenoir [67] (1887), Savariaud [68] (1906), Martini [69] (1904), Fasano [62] (1908), and Pilliet and Pasteur [70] (cited by Deroyer) are likewise unmentioned, so that the relative frequency of sarcoma is probably even higher than one would suppose from the reports of these authorities.

One other case has been reported in this country (Brand,[71] 1916), and deserves mention because of its unusual nature. The onset of the growth dated from two months after an operation for the removal of a testicle, in a patient of 26 years, suffering from acute gonorrheal orchitis. Local removal of the growth resulted in a two year cure.

Sarcomas of the cord occur as fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, spindle cell or giant cell sarcoma, or various combinations of these types. Fibrosarcoma appears to be the most common type, and such cases are reported by Panteloni,[72] Martini,[69] Savariaud [68] and others. Myosarcoma is extremely rare. Cases are reported by Pepper,[43] Quénu,[73] Walsham [14] and Dupouy.[74] This type forms the subject of the thesis of Fonteneau.[75] Clinically, it is very frequently the case that these growths have origin in a benign tumor of long duration and slow evolution (Tédénat and Martin [22]). They

64. Maylard: Specimens of True Bone Which Had Developed Within a Sarcoma of the Spermatic Cord, Tr. Glasgow Path. & Clin. Soc. **5**:201-203, 1893-1895.

65. Mason: Sarcoma of the Spermatic Cord, with Hernia of the Vermiform Appendix, Med. News **42**:554-556, 1883.

66. Lemarque: Sarcome du cordon spermatique; extirpation, J. de méd. de Bordeaux **17**:280, 1887-1888.

67. Lenoir: Sarcome du cordon spermatique, Bull. Soc. anat. de Paris **62**:130, 1887.

68. Savariaud: Volumineux fibrosarcome du cordon spermatique, Soc. anat. de Paris, May, 1906.

69. Martini: Fibrosarcoma del cordone spermatico, Bull. de Chir., Milano, 1904, p. 344.

70. Pilliet and Pasteur: Myxo-Sarcome du Cordon, Soc. anat., 1897.

71. Brand: Primary Perithelial Sarcoma of the Spermatic Cord, New York M. J. **104**:454 (Sept. 2) 1916.

72. Panteloni: Un cas de fibrosarcome du cordon, Arch. prov. de chir., Paris **10**:226-232, 1901.

73. Quénu: Myxo-sarcome du cordon spermatique, Bull. et mem. Soc. de chir., Jan. 29, 1902.

74. Dupouy: Lipo-myxo-sarcome du cordon, Semaine méd., 1891, p. 400; Tumeur mixte du cordon spermatique, Ass. franç. p. l'avance d. sc., C.-r., Paris **20**:774, Pt. 2; 1897-1892.

75. Fonteneau: Contr. a l'étude des tumeurs malignes du cordon, Thèsis (Bordeaux), 1908.

liken these tumors to mixed tumors of the parotid in this respect, when a benign stage of long duration followed by malignant degeneration, with sudden increase in growth, is a classic feature. Sarcoma of the cord is practically always scrotal, rarely inguinal (as was the case of Tédénat and Martin [22]), and the growth rarely extends upward into the inguinal canal. In some cases, it can be enucleated, leaving the cord intact; in others, the cord is buried within the mass and is inseparable. In the former case, it is surmised that the growth is funicular or perifunicular in origin, and in the latter that it arises from the elements of the cord proper.

These growths have little respect for age limits, as Table 1 illustrates. Six out of twenty, or 30 per cent., occurred in the fifth decade, but none is exempt from involvement.

The clinical course of sarcomas of the cord and the results of treatment parallel those of teratoma testis, if we may judge from the few reports in the literature. However, reports of results are too few to permit of detailed analysis, and so, until further evidence accrues, they should receive the same radical treatment accorded testicular tumors. The lymphatics of the testicle drain directly into the retroperitoneal lumbar lymph nodes along the aorta and vena cava. The same holds true for the epididymis, spermatic cord and testicular tunics. The inguinal glands are involved secondarily to involvement of the skin, a very rare complication.

Mixed Tumors.—Analysis of cases reported as mixed tumors and teratomas of the cord reveals a confusion of terminology and lack of detail, which in many cases casts doubt on their authenticity, as, for example, the case of Pringle [76] (1856), who reports a cystic cephaloma of the cord weighing 6.5 pounds (about 3 kg.), of which no microscopic examination was made. A somewhat similar case is reported by Faisant [77] (1905), which is presented here in summary because of its unique character:

> A man, aged 67, had noted, when 10 years of age, a small lump above the left testis, which he attributed to a kick. It remained unchanged in size for thirty-two years. At the age of 42, he suffered a severe contusion of that region, and the mass began to grow slowly. In ten years, it had reached the size of a goose egg. Suddenly, without apparent cause, it began to increase rapidly in size and became painful, and in less than a year reached the weight of 2,080 gm. It was removed and was found to involve the cord, the testis being quite normal. Microscopic examination revealed cartilage, and other mesoblastic tissues.

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76. Pringle: Cystic Cephaloma, Arising from the Membranes of the Spermatic Cord; Excision; Death from Peritonitis Six Days After the Operation, Lancet **2**:94, 1856.

77. Faisant: Tératome du cordon, Lyon méd. **105**:378-380, 1905.

This case was reported as that of a teratoma, yet from the microscopic description it appears to have been of a sarcomatous nature. Patel and Chalier,[4] and Sebileau and Descomps [78] place in the group of mixed tumors and teratomas the myxosarcomas of Walsham,[14] Quénu,[73] etc.; the myxochondrosarcoma of Pepper,[43] the lipomyxosarcoma of Duplouy,[74] the fibromyxosarcoma of Porges,[79] the myxolipofibrosarcoma of Karewski [80] and the myxochondrofibrosarcoma of Herfarth.[81] Even if we considered these as monodermal derivatives of tumors primarily tridermal in nature (a rather strained supposition), the fact that teratomas rarely exhibit sarcomatous changes (Schultz and Eisendrath [82]) is strong evidence against their teratomatous origin.

One other case of interest may be mentioned here; that of Pignatti [83] (1914), which he regards as that of an epithelioma funiculi arising from the ductili aberrantes. From the drawings and description, the

TABLE 1.—*Age Incidence in Mesoblastic Tumors*

Years	Number of Cases
0 to 10	3
11 to 20	1
21 to 30	1
31 to 40	2
41 to 50	6
51 to 60	2
61 to 70	2
71 to 80	3

growth appears to be a true seminoma of Chevassu (embryonal carcinoma of Ewing,[84] spermatocytoma of Schultz and Eisendrath [82]). Its origin was in the tissues about the superior pole of the testicle, and there was a metastatic nodule in the tunica albuginea. The vas was normal, as was also the testicle, except for slight atrophy. The patient showed signs of metastases fourteen months after castration.

78. Sebileau and Descomps: "Maladies des organes genitaux de l'homme," Nouv. Traité de Chir. (Le Dentu et Delbet) **32**:213, 507, 674, 679, 1916.

79. Porges: Ein teratoider Tumor am Hoden (Lipom des Samenstranges), Wein. klin. Wchnschr. **10**:649-653, 1897.

80. Karewski: Sur un cas de tumeur géante de la tunique vaginale, Semaine méd., July 4, 1894, p. 314.

81. Herfarth: Inaug. Dissert., Marburg, 1891.

82. Schultz, O. T., and Eisendrath, D. N.: The Histogenesis of Malignant Tumors of the Testicle, Arch. Surg. **2**:493-520 (May) 1921.

83. Pignatti: Di un raro caso di tumore del cordone spermatico, Clin. chir. **22**:2297-2308, 1914.

84. Ewing, James: Neoplastic Diseases, Philadelphia, W. B. Saunders Co., 1921, p. 779.

BENIGN TUMORS OF THE EPIDIDYMIS

Epithelial Tumors.—No tumors of this nature have been found in our perusal of the literature.

Mesoblastic Tumors of the Epididymis.—Lipoma: A single reference to lipoma of the epididymis has been found, that of Wildbolz [85] (1914), the chief reason undoubtedly being the fact that the epididymis normally contains no fat, although a little may be found in the connective tissue coverings. It was apparently from the latter that the tumor had its origin in the case of Wildbolz. The patient was 45 years of age, and had become neurotic over a small, nodular, painless swelling of the left epididymis. He had a negative venereal history. Epididy-

TABLE 2.—*Summary of Six Cases of Leiomyoma*

Author	Year	Age of Patient, Years	Trauma	Duration, Years	Fluid in Tunica Vaginalis	Size of Tumor	Treatment	Results
Hericourt...	1885	34	Gonorrhea and epididymitis 15 years before (same side)	7	+	Walnut	Castration	Not stated
Hericourt...	1885	45	Gonorrhea and epididymitis 31 years before (opposite side)	2	+	Walnut	Removal	Not stated
Terrillon....	1885	31	Gonorrhea and epididymitis 11 years before	5	..	Small walnut	Removal	Well 3 months later
Rindfleisch..	1886	..	.....	...	..	Pullet egg		
Condamin..	1887	35	Blow immediately preceding	7 mos.	+	Mandarin orange	Operation	Cure
Schultz and Eisendrath	1921							

mectomy was performed; recovery was uneventful, and there was no sign of recurrence four years later. Examination of the specimen showed the body and tail of the epididymis to be normal, but the head enlarged and nodular. On section of the mass several small lobules of fat in the epididymis were seen, taking origin from the connective tissue covering. They varied from 5 to 7 mm. in diameter, and were encapsulated. There were some smaller nodules not so sharply encapsulated, undergoing transition in the direction of the normal fat lobules occurring in this connective tissue sheath. These were considered as not having reached the lipomatous stage. There was a slight amount of inflammatory infiltration of the gland substance, particularly about the small vessels in the stroma.

85. Wildbolz: Ueber Lipome des Nebenhodens, Ztschr. f. Urol. **8**:453-459, 1914.

Fibroma and myxoma: Reference has been made to the confusion existing in the literature as to the exact point of origin of certain fibromas, yet on careful analysis they appear to have arisen in the cord or the tunica vaginalis rather than in the epididymis, so that it is doubtful that an authentic case of fibroma or myxoma of the epididymis has been recorded.

Leiomyoma: Six cases of leiomyomas of the epididymis, which can be accepted, have been reported. They are summarized in Table 2.

Cystic dermoid: No reports of cystic dermoids of the epididymis were found in the literature. The fact that dermoids have not occurred in this region is difficult to explain, considering the number which have been reported as cord tumors.

TABLE 3.—*Summary of Four Cases of Carcinoma of Epididymis*

Author	Age, Years	Side	Trauma	Duration	Treatment	Results	Diagnosis
Wröbel.....	24	Left	Gonorrhea 1 year before	1 year	Castration	Died 13 years later from unknown cause	Primary carcinoma
Rowlands and Nicholson	46	Right	None	1 year	Castration	Died 14 months later; edema of right leg	Squamous epithelioma
Sakaguchi.....	18	Left	None	14 weeks	Castration	Died 1 year later; metastasis to lungs and retroperitoneal glands	Primary carcinoma
Hinman and Gibson	78	Left	9	11 mos.	Epididymectomy	Well 8 months after operation	Adenocarcinoma

MALIGNANT TUMORS OF THE EPIDIDYMIS

Epithelial.—Carcinoma: Three cases of carcinoma of the epididymis have been reported which may be regarded as authentic; the cases of Wröbel [86] (1902), Rowlands and Nicholson [87] (1909) and Sakaguchi [88] (1914). A personal case is included here rather than with the benign epithelial growths, since Ewing considers it an adenocarcinoma. Stout [89] (1917) discussed conditions of the epididymis simulating cancer, and reported a case showing epithelial changes which may be regarded at least as precancerous.

86. Wröbel: Beiträge zur Kenntnis der Malignen Hodengeschwulste, Breslau, 1902.

87. Rowlands and Nicholson: A Case of Primary Squamous Celled Epithelioma of the Epididymis, Lancet, London, 1909, p. 304.

88. Sakaguchi: Ein Fall von primären Karzinom des Nebenhodens, Frankfurt Ztschr. f. Path. **15**:62-78, 1914.

89. Stout: Conditions of the Epididymus Simulating Cancer, Proc. New York Path. Soc. **17**:129-137, 1917.

Sakaguchi's description of the specimen in his case is complete and well illustrated. Microscopically, the general picture was one of solid fields of cells closely resembling the normal epithelial cells of the epididymus. The cells contained each a single nucleolus, and typical and atypical mitoses were frequent. The cell proliferation occurred within the canaliculi and partly through the lumina of veins. Necrosis was present in the center of some of the cell masses. The testicle showed early invasion, and there was an anemic infarct at its lower pole. The metastases showed the same microscopic picture.

We wish to report here a personal case of most unusual character, because no similar case has been found in the literature, and particularly because of the uncertainty and difference of opinion existing among some of the leading pathologists in this country as to the exact nature of the tumor, and as to whether or not it was malignant.

CASE 2.—*History.*—Mr. J. B., aged 78, a coffee importer, who was referred by Dr. J. L. Boehm, New York, complained of a mass in the left side of the scrotum. The family history was unimportant. The patient has always enjoyed excellent health, and had had no serious illnesses. No history of venereal infection was elicited. The patient's habits were good.

About eleven months previously, he first noticed a nodular condition in the left side of the scrotum. Since then, the skin had gradually retracted over the nodules, but there had been no ulceration or drainage. There have been no symptoms except, of late, an occasional slight drawing sensation in the scrotum. The patient could recall no trauma in that region.

Physical Examination.—The patient was well developed and well nourished, in excellent physical condition for his age. Blood pressure was 140 systolic, 80 diastolic. Nothing abnormal was found. There was no evidence of tuberculosis anywhere. The Wassermann reaction was negative; blood picture, normal; urine analysis, negative; acid fast stain of sediment, negative.

The entire epididymis was very irregular and nodular, and of hard, rubbery consistency. The testicle proper felt entirely free and normal. The skin over the indurated areas was puckered and markedly adherent. Some isolated nodules could be felt up as high as the external abdominal ring. The inguinal glands were not felt, nor was there any evidence of enlargement of the abdominal glands. The impression gained was that of an old sclerosing tuberculous epididymitis, which had secondarily involved the skin, but had not broken through. The possibility of fibroma or gumma was also to be considered.

Operation.—July 13, 1922, under nitrous oxid and oxygen anesthesia, an incision about 7 cm. long was made over the left epididymus. In the middle of the incision, a small area of skin, about 3 cm. in diameter, was circumscribed, owing to its adherence to the tumor underneath. The incision was then developed through the subcutaneous tissues down to the tunica vaginalis. This was found to be markedly adherent to the tumor. The cord was identified and freed by blunt dissection with the gloved finger in the upper part of the incision. Careful inspection showed that the tumor involved the entire epididymis and was markedly adherent everywhere, especially to the median septum and the base of the left corpus cavernosum. Examination of the cord and of the body

of the left testicle showed that they were perfectly normal in appearance and free from tumor invasion. The epididymis was easily separated from the testicle; the cord was dissected free and cut at the level of the external inguinal ring, and both structures were removed intact, together with the surrounding adherent tunics and overlying skin (Fig. 6). The testicle with its blood supply was left in situ. The scrotum was buttonholed about 1 cm. below the incision, and a Penrose drain was inserted through it into the scrotal cavity. The wound was carefully closed with subcutaneous catgut sutures and a cutaneous running locked suture of black silk.

Postoperative Course.—The patient made an uneventful recovery, except for some sloughing of the wound margins, where there still remained some of the

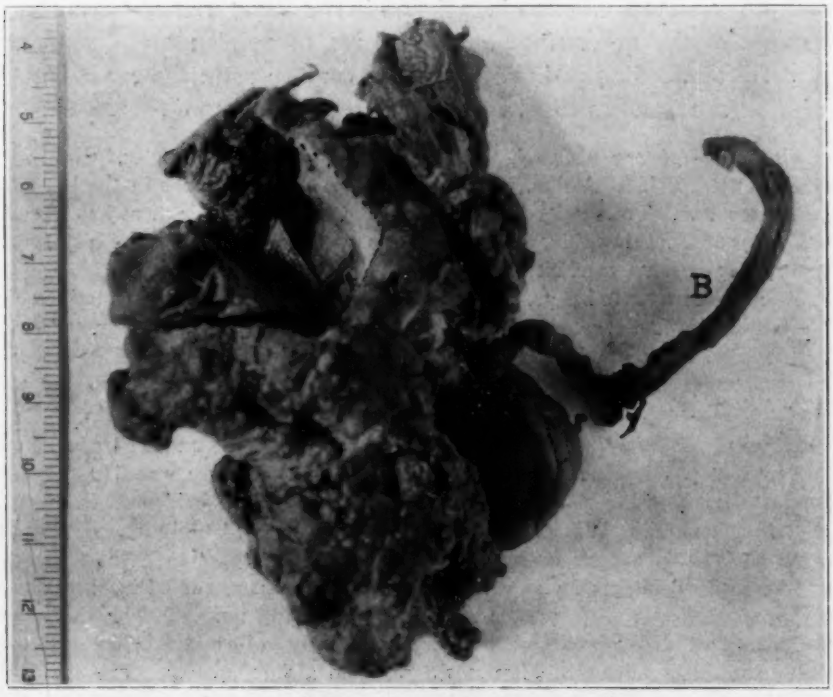

Fig. 6 (Case 2).—Tumor mass involving epididymus with skin of scrotum adherent (*A*), and cord attached (*B*). The dotted line shows areas from which blocs were removed for microscopic study.

puckered adherent skin which had a very poor vascular supply. However, healing was eventually perfect, and now, eight months after operation, the patient is perfectly well and shows no evidence of recurrence or metastasis.

Pathologist's Report.—The specimen consisted of the vas deferens and epididymis (Fig. 6), surrounded by a great deal of fibrous tissue, with skin attached and adherent (Fig. 6 *A*). On section through various parts, the epididymis appeared to be replaced almost entirely by dense fibrous tissue, to which the skin was directly adherent. Occasional groups of small glandlike

structures were made out in the midst of fields of fibrous tissue, but they possessed no visible lumina. No tuberculous nodules, caseation or sinus formation was made out. The cord appeared normal and disappeared in the mass at its superior pole. Sections from representative areas, on microscopic formation, presented a striking picture of tubules of all sizes and shapes (Figs. 7, 8, 9 and 10), more or less widely separated by dense connective tissue, the cells of which were of the adult fibrous tissue type.

One did not see the embryonic connective tissue cells which would be expected with a malignant epithelial tumor. The gland structures possessed

Fig. 7 (Case 2).—Low power microscopic view of tumor (Fig. 6), showing glandular type of proliferation, with dense intervening fibrous stroma. The epithelial cells are small and darkly staining.

a thin basement membrane which appeared lacking or broken through in areas. The glands in some areas appeared very much compressed by fibrous overgrowth; in other areas, they seemed dilated and the lining epithelium was flattened. The cells were small, with hyperchromatic nuclei possessing a single nucleolus. These cells resembled somewhat endothelial cells, especially the flattened ones lining the dilated tubules. Mitoses were infrequent. The tubules appeared quite different in structure from the normal tubules of the epididymis,

a small group of which were seen in a section through the region of the globus major where the vas disappeared in the mass. They lacked the heavy muscularis and columnar type of cell seen in tubules of the epididymis. Beneath the skin, a dense layer of connective tissue interspersed with smooth muscle fibers of the dartos was seen. The skin itself was normal, but was firmly adherent to the underlying fibrous tissue. The gland structures did not come in contact with the skin anywhere, but were separated by more or less dense connective tissue (Fig. 8). Groups of epithelial cells were seen growing between and

Fig. 8 (Case 2).—Low power microscopic view showing skin and underlying fibrous tissue. The proximity of the epithelial proliferation to the skin is best illustrated in this section.

about arteries and veins and bundles of the dartos muscle. The vas was normal.

A definite diagnosis was not made. It was thought possibly to be a fibro-adenoma; but the indefinite limits of the neoplasm and the involvement of the surrounding structures militated against this view. Its malignancy was considered doubtful by Drs. Bartlett and Rusk.

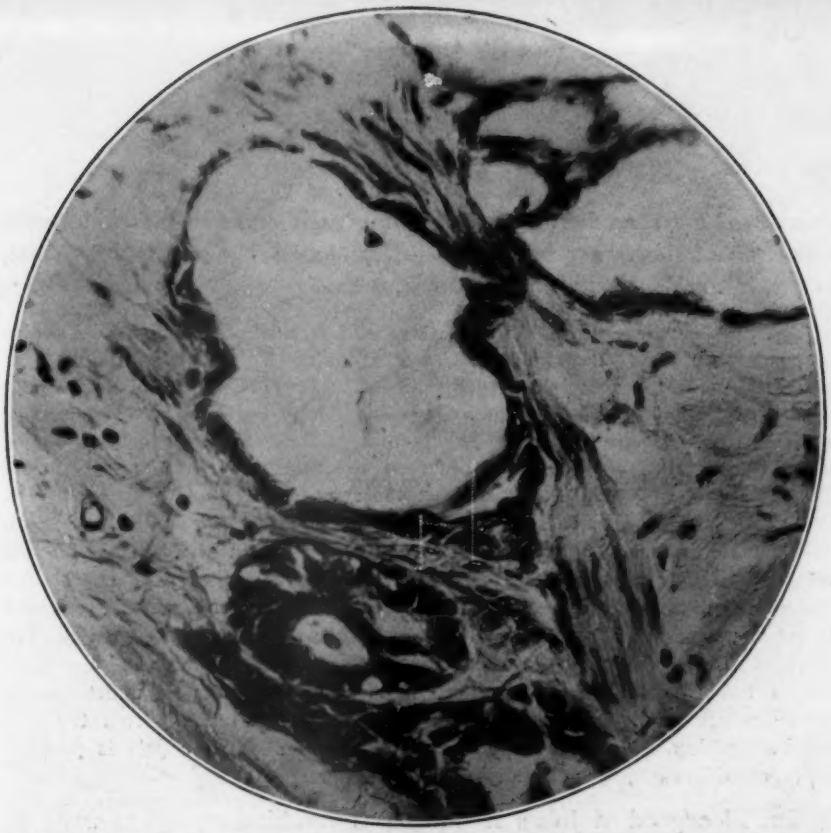

Fig. 9 (Case 2).—High power microscopic view of area shown in Figure 7. The cell types and character of proliferation may be noted.

Fig. 10 (Case 2).—High power microscopic view of area shown in Figure 7.

Since we had never before seen this unusual picture in the epididymis, a portion of the tumor was taken to Dr. James Ewing of New York, at Dr. Boehm's solicitation. Dr. Ewing said:

> Structurally, your tumor of the epididymis is an adenocarcinoma, being composed of widely scattered acini lined by flat or often cubical epithelioid cells in which nuclei and nucleoli are prominent. Many of the acini are widely dilated and the lining cells flattened so that these portions recall a lymphangioma. The general structure recalls that of the rete testis, but the tumor seems to have been entirely separate from the testis, so that an origin from the rete is not easily adjusted. That it has some malignancy is shown by the infiltration of the skin, but I should not regard it as very malignant. I am quite unable to reach any conclusion regarding the origin of the tumor. Some years ago I saw a very similar growth removed from the cord, and I concluded that it was a lymphangioma, but this conclusion can hardly be regarded as satisfactory. The occurrence of such a tumor suggests to me a search for aberrant canals of embryonal origin in this locality which might give rise to such a tumor. This region abounds in peculiar structures of undetermined nature, which might give rise to tumors. Of aberrant canals from the rete I know nothing. The possibility of an origin from lymph canals is perhaps worth considering, but lacks any definite support.

Dr. Bloodgood of Johns Hopkins was also kind enough to write us his opinion:

> The tumor is composed of acini lined by cells of the epithelial type, the cells sometimes proliferating, and in a few instances solid. There is no definite basement membrane and this adenomatous tumor extends up to the epidermis of the scrotum. This growth of adenomatous tissue growing up to the epidermis favors malignancy. The complete absence of cells in many places in the basement membrane and here and there nests of cells as we see in cancer favors malignancy. I have never seen a tumor of this kind in the epididymis, but if this was in the breast and the tumor extended to the skin I would treat it as cancer. If this tumor would recur or metastasize, it would settle the diagnosis. If it does not, then we do not know. I also notice here and there papillary growths so that we have cystic adenoma, papillary cystadenoma and cancer.

Dr. Ophuls of the department of pathology of Stanford University Medical School kindly examined the specimen grossly and microscopically and substantiated Ewing's view, stating that it was without doubt a scirrhous adeno-carcinoma of probably a low degree of malignancy. However, he considered the possibility of its being an endothelioma, and also questioned its epididymal origin.

It should be noted further that, although this growth proved to be clinically a tumor of the epididymis, its point of primary origin may have been in some neighboring structure. The same holds true for our other cases reported in this paper, and for testicular tumors in general. Although tumors of the testicle exist as such clinically, their actual point of origin remains to be determined, in view of the numerous

vestigial embryonic and adult structures which lie in close apposition about the testicle and which might serve as a starting point for the neoplasms commonly encountered in this region.

MESOBLASTIC TUMORS OF THE EPIDIDYMIS

Sarcoma.—Sarcoma appears to be the most frequent tumor of the epididymis. It has been shown elsewhere (Ewing,[84] Schulz and Eisendrath [84]) that most of the many reports of sarcoma testis occurring in the literature are misnomers, and consequently the reports of sarcoma of the epididymis must be accepted reservedly, particularly as regards the older contributions to the subject.

The earliest reports available are those of Lebert [90] (1845), who reported a case of encephaloid disease of the epididymis in which the testicle was intact, and those of Robin and Ordonez,[91] who, on the basis of cases met with in their experience, attempted to establish the proposition that "sarcocèles encéphalóides et kystiques" of the testicle have their origin in the epididymis, and not in the testicle. They recorded a case of a tumor measuring 10 by 7.5 cm. arising in the tail of the epididymis, the testicle being perfectly intact. The tumor was composed mostly of fibrous tissue and a fetal type of cartilage undergoing ossification.

In 1859, Erichsen [92] reported a case of encephaloid disease of the epididymis in a boy of 16 years. The tumor was the size of a coconut and of seven months' duration. At operation, the testicle was found to be normal. No further details are given.

Arrachart,[93] in 1861, reported a case each of "sarcocèle encéphalóide" and "sarococèle kystique," in support of the contention of Robin and Ordõnez.[91] In the former case, he speaks of cancerous elements, but the exact pathologic nature of either tumor is not clear.

Lagrange,[94] in 1872, recorded a case of "sarcome encéphaloide," but the description is so inadequate that one is inclined to doubt that it was actually a neoplasm.

Ten cases have been reported since 1872 which we believe may be accepted without question: a case of chondrosarcoma (Curling,[95] 1882);

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90. Lebert: Physiologie Pathologique **2**:339, 1845.

91. Robin and Ordõnez: Note sur le siège et la structure des tumeurs mixtes, fibro-plastiques, et cartilagineuses, de l'épididyme, Arch. gén. de méd., Paris **2**:175, 1856.

92. Erichsen: Encephaloid Disease of the Epididymis, Lancet **2**:86, 1859.

93. Arrachart: De l'origine épididymaire des tumeurs dites encéphalóides ou kystiques du testicule, Bull. méd. du nord **2**:128, 1861.

94. Lagrange: Sarcome encéphalóide de l'épididyme, Bull. Soc. anat de Paris **47**:229, 1872.

95. Curling: Cystic Chondro-Sarcoma of the Epididymis, Tr. New York Path. Soc. **1**:119, 1881-1882.

a case of spindle cell sarcoma (Edwards,[96] 1887); three cases, of sarcoma, melanosarcoma and spindle cell sarcoma, respectively (Kocher and Langhans,[97] 1887); a case of melanosarcoma (Rydigier,[98] 1891); a case of spindle cell sarcoma (Russell and Wood,[99] 1899); a case of lymphosarcoma (Kolster,[100] 1899); a case of sarcoma (Grossman,[101] 1900), and finally a case of chondrosarcoma (Spandri,[102] 1904). Analysis of these cases shows that their clinical course closely parallels that of teratoma testis, which does not need repetition here.

Miyata [103] (1913) studied twenty-seven testicular tumors, of which three are briefly reported as arising outside the testis: a fibrosarcoma of the tunic of the epididymis; a spindle-cell sarcoma of the sheath of the spermatic cord, and a spindle-cell sarcoma of the tunic of the testicle.

Teratoma.—Teratoma of the epididymis does not occur, judging from the paucity of literature on the subject. Omitting from consideration the "sarcocèles encephalóides et kystiques" and the reports of sarcomas, we have but the single instance recorded by Barringer [104] of a true teratoma occupying the entire epididymis, with extremely little encroachment on the testicle, although Bland-Sutton [105] has reported a teratoma as arising between the testicle and epididymis. It is the belief of the latter that testicular tumors arise from the paradidymis. The consensus of opinion as expressed by Ewing [84] is that testicular tumors arise in the rete testis. It is therefore probable that, in the case of Barringer,[104] the point of origin was the same as for teratoma testis, but for some unknown reason the propagation was primarily into the epididymus rather than along the customary route into the testis.

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96. Edwards: Spindle-Celled Sarcoma of Epididymis, Tr. Path. Soc. **38**:221, 1887.

97. Kocher and Langhans: Krankheiten d. männl. Geschlechtsorgane, Deutsch. Chir. **50**, 1887.

98. Rydigier: Ein Fall von primärem Melanosarkom des Nebenhodens, Arch. f. klin. Chir. **12**:769, 1891.

99. Russell and Wood: Sarcoma of the Epididymis, Removal, Brit. M. J. **2**:1193, 1899.

100. Kolster: Seltene Sektionsbefunde (Fall IV), Virchows Arch. f. path. Anat. **155**:391, 1899.

101. Grossman: Zur Kenntnis der auf traumatischer Grundlage entstandenen Hodensarkome, Ing.-Diss., München, 1900.

102. Spandri: Condro-sarcoma dell'epididimo, Riv. Veneta di sc. med., Venezia **41**:167-171, 1904.

103. Miyata: Zur Kenntniss der Hodengeschwülste und die Bedeutung des Traumas fur ihre Entstehung, Arch. f. klin. Chir. **101**:426, 1913.

104. Barringer: Report of a Case of Teratoma of the Epididymis, Internat. J. Surg. **33**:116, 1920.

105. Bland-Sutton: An Improved Method of Removing the Testicle and Spermatic Cord for Malignant Disease, Lancet, 1909, p. 1406.

Fig. 11 (Case 3).—Exterior view of testicle.

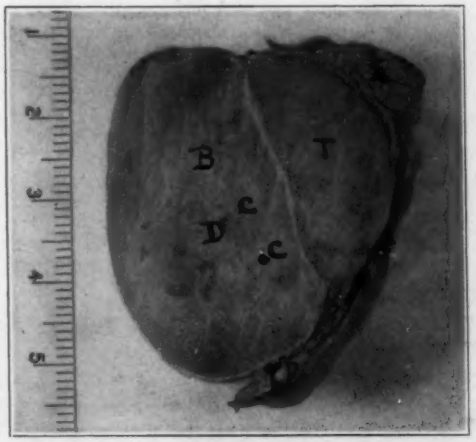

Fig. 12 (Case 3).—Sagittal section of testicle: *E*, epididymis; *T*, malignant tumor (seminoma); *B*, atrophic testicle; *A*, margin of normal gland tissue; *D*, area of necrosis and hyalinization. The solidity of the tumor mass and its circumscribed margin are evident. There is a definite line of demarcation between tumor and testicle, and the compressed shell of the epididymis can be peeled off the tumor everywhere except at the upper pole, to which it is intimately attached. A few small foci of tumor cells are present in the testis at the points marked *C*.

We are indebted to Dr. S. R. Dannenbaum of this city for permission to report the following unique case of seminoma of the epididymis:

Case 3.—*History.*—Mr. I. S., aged 27, a merchant, married, with no children, and whose family history was negative, was born with an undescended left testicle, situated anterior to the external ring, at time tender, but seldom painful. There was occasional pain and swelling in the testicle, which subsided in a few days, the last attack, three months previously, being due to a sudden strain on lifting.

Physical Examination.—The patient's weight was 92 pounds (about 42 kg.); height 5 feet and 2 inches (1.55 meters). He had enjoyed good health all his life though he was never very robust. His mental state was always excellent, although he was inclined to be slightly nervous. At all times, he was able to attend to his duties as a merchant. Intercourse was normal, though at times there was pain in the left testicle.

Laboratory Findings.—Blood count revealed: erythrocytes, 4,800,000; leukocytes, 7,400; hemoglobin, 90 per cent. The urine was negative. The Wassermann reaction was negative.

Operation.—Dec. 5, 1922, under local anesthesia (procain, 0.5 per cent.) the testicle was removed. It was enlarged to the size of a hen's egg. The wound closed, and healed by first intention. Recovery was uneventful.

Pathologist's Report.—The specimen consisted of an ovoid mass about the size of a normal testicle (Figs. 11 and 12). The surface was smooth and free from adhesions; the epididymis was well outlined, and the digital fossa was present. The epididymis appeared slightly more prominent than the normal. On section, the testis appeared fibrotic except for a narrow margin of normal brownish gland tissue opposite the epididymis. The body of the epididymis was replaced by a solid opaque circumscribed tumor mass, which appeared to be separated from the testicle by a definite capsule. The globus major and globus minor were preserved. No areas of necrosis were made out. Microscopic examination of representative sections (Figs. 13, 14 and 15) showed that the parenchyma of the testis had undergone atrophy, except for a narrow strip beneath the tunica albuginea opposite the epididymis, where normal seminiferous tubules were seen.

There was a small area of necrosis and hyalinization near the center of the atrophic area. Throughout the atrophic portion, particularly in the region of the rete, were small collections of cells of the same type as in the tumor proper. These foci were spherical and indistinctly circumscribed, and varied in size from a few cells to foci visible grossly in the stained section (Fig. 13). The tumor was separated from the testicle by a compressed fibrous capsule and could be shelled out from the epididymis except at the superior pole, where it was inseparable from the structure. The tumor consisted of the large, spherical medullary type of cell, resembling spermatoblasts, growing in solid formation for the most part, but with a tendency here and there to alveolar formation, and supported on a heavy lymphoid stroma, which in places almost overshadowed the large cells.

This is the typical picture of the seminoma of Chevassu (embryonal carcinoma of Ewing,[84] spermatocytoma of Schultz and Eisendrath[82]).

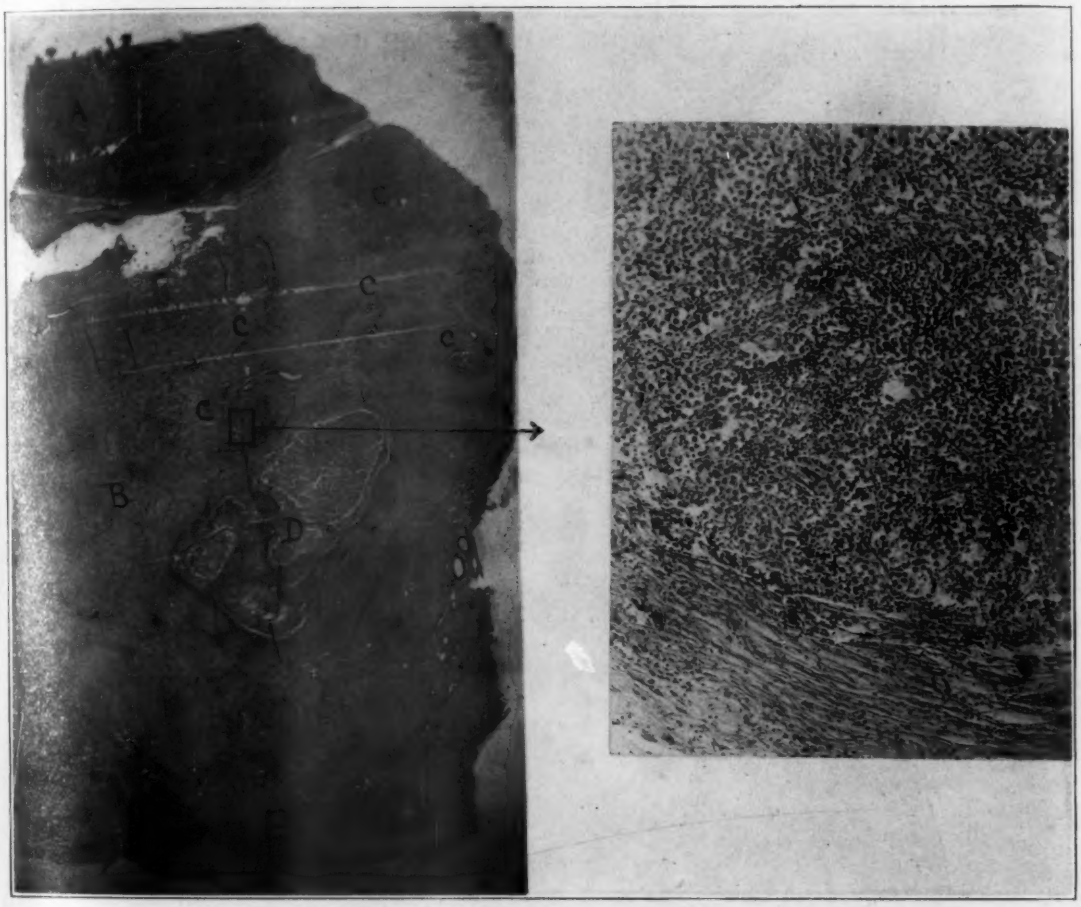

Fig. 13 (Case 3).—Left: Transverse section of testicle, natural size: *A*, tumor; *B*, atrophic testicle; *C*, tumor nodules; *D*, area of necrosis and hyalinization; *E*, margin of normal gland tissue. Right: Low power microscopic view of a tumor nodule in the testis, illustrating the large medullary type of cell, supported on a lymphoid stroma characteristic of seminoma.

Fig. 14 (Case 3).—Low power view of edge of main tumor, showing fibrous capsule separating it from the testicle.

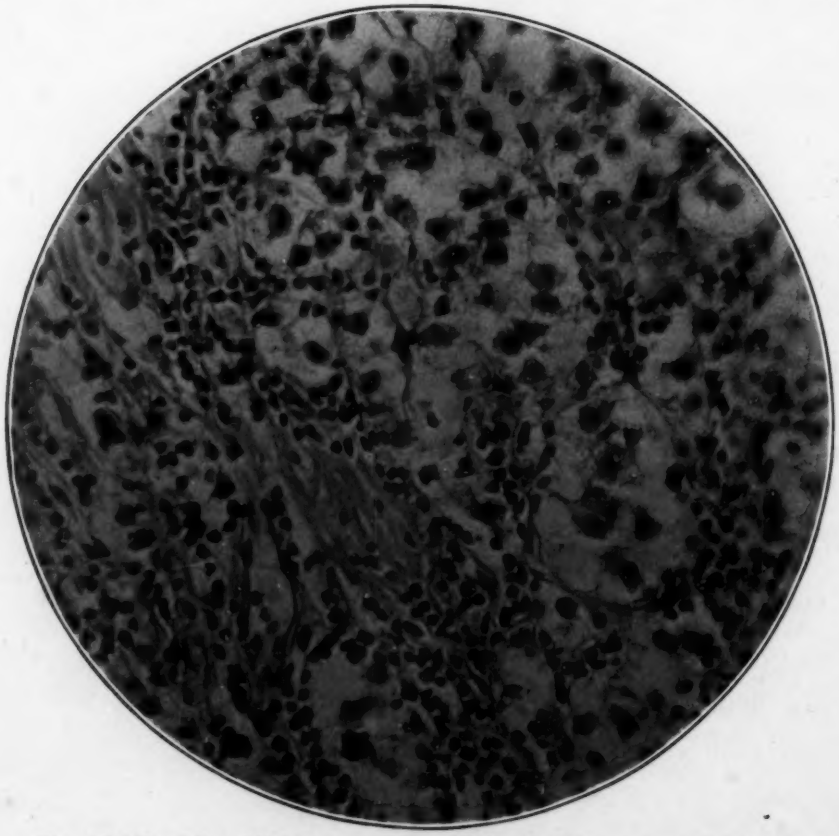

Fig. 15 (Case 3).—High power microscopic view of section of main tumor (Fig. 12 *T*), illustrating characteristic type of growth (seminoma).

COMMENT

The finding of foci throughout the testicle itself in this case of tumor cells belonging to a type of neoplasm ordinarily found in that organ raises the question as to the primacy of the tumor. The fact that the foci in the testicle are small and multiple, and vary in size, favors the epididymis as the primary site of the tumor, or at least suggests that the tumor arose outside the testis. In a personal communication, Ewing says:

> Regarding encapsulated cellular tumors of the testis, separate from the organ, and of the type of seminoma, I have seen several, and have come to regard them as typical of the early stages of embryonal carcinoma of the testicle. As you say, the occurrence of such tumors stands strongly against Chevassu's idea of their origin, and was one of the chief reasons why, in my old article on this subject, I was unable to accept Chevassu's view.

TUMORS OF THE TESTICULAR TUNICS

A glance at the literature will illustrate the comparative importance of tumors of the tunica albuginea and those of the tunica vaginalis.

Tumors of the Tunica Vaginalis.—Klebs,[106] Kocher,[107] Orth,[108] and Monod and Terrillon [109] have emphasized the difficulty of differentiating tumors of the tunica vaginalis from those arising in adjacent structures. Excellent contributions to the general subject of tumors of the tunica vaginalis are those of Minet [110] (1896) and Grote [111] (1908). Probably the earliest reference to the subject is that of De Rooy [112] (1823), to which we did not have access.

Adenoma: Two authentic cases have been recovered from the literature: that of Mühsam [113] (1898), in which a small adenomatous tumor of benign character was discovered on the inner wall of the tunica vaginalis during an operation for hydrocele on a man of 36 years, and that of Nicolopoulo [114] (1895), in which a benign epithelioma

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106. Klebs: Pathol. Anat. **1**:1071, 1885.

107. Kocher: Krankheiten der männlichen Geschlechtsorgane, Deutsch. Chir., 1887, p. 183.

108. Orth: Pathol. Anat. **2**, 1893.

109. Monod and Terrillon: Traité des maladies des testicules, 1889.

110. Minet: Sur les tumeurs solides des tuniques du scrotum, Thèsis (Lille), 1896, No. 139.

111. Grote: Ueber Geschwülste der Tunica vaginalis propria, Inaug. Diss., Göttingen, 1908.

112. De Rooy: De insigni tunicae vaginalis testis degeneratione, aliorumque organorum vitiis, in cadavere senis 104 annorum observatis, Ludg. Bat., 1823.

113. Mühsam: Beitrag zur Kenntniss der Geschwülste der Tunica vaginalis, Deutsch. Ztschr. f. Chir. **49**:583, 1898.

114. Nicolopoulo: Sur un cas d'épitheliome primitif de la sereuse vaginale, Thèsis de Paris, 1895.

of cystic and papillary nature in a man of 65 years was discovered at an operation for traumatic hydrocele. Numerous vegetations were present over the entire serous surface of the tunica vaginalis in the latter case.

Lipoma: So far as we have been able to judge, the only authentic case of lipoma reported is that of Park [115] (1886) in this country, in which a lipoma of eighteen months' duration and weighing 12 pounds (5.4 kg.) distended the right tunica vaginalis of a man of 40 years. Kocher [106] has described a questionable case, and Gascoyen [116] (1886) reported a case of lipoma weighing 5 pounds (2.3 kg.), arising from the lowermost portion of the cord and possibly having its origin in the tunica vaginalis.

Fibroma: Approximately thirteen cases of fibromas of the tunica vaginalis which may be accepted have been reported. Probably the earliest case to be reported was that of Poisson [117] (1858). Home and Heath [118] reported a case in 1869, and in 1875 Reclus [119] reported a case of fibrous bodies arising in the tunica vaginalis following irritating injections. Thikonovich [120] reported a similar case apparently resulting from trauma. Kocher [107] (1887) and Jacobson [121] (1893) reviewed three cases of single large fibromas. Curling [7] reported such a case in 1878. Other cases have been reported by Baizeau [122] (1861), Karewski [80] (1894) and Challiès [123] (1896).

Balloch's [124] case is of interest, as it is the only case reported in this country that we have been able to find. The patient was a negro boy of 18 years, who had a tumor in the scrotum of eight years' duration. Orchidectomy was performed, and the tumor mass was found to consist of three large nodules embedded in the tunica vaginalis. The latter, as well as the tumor, had undergone marked myxomatous degeneration. The testicle was normal, except for a moderate amount of myxomatous degeneration. The tumors, after they were shelled out from the tunica, weighed, in toto, 1,077 gm. The tunica vaginalis itself weighed 567 gm. There was no definite history of trauma in this

115. Park: Lipoma Testis, Philadelphia Med. Times, May 15, 1886; Ann. Surg. **3**:356, 1886.

116. Gascoyen: Tr. Path. Soc., London **17**:176, 1886.

117. Poisson: Fibromes de la Vaginale, Thèsis (Paris), 1858.

118. Home and Heath: Fibroma of the Tunica Vaginalis, Tr. Path. Soc., London, 1869, pp. 184, 286.

119. Reclus: Bull. Soc. anat. de Paris **1**:327, 1875.

120: Thikonovich: Khirurgiya, Mosk. **10**:630, 1901.

121: Jacobson: Diseases of the Male Organs of Generation, 1894, p. 434.

122. Baizeau: Union méd. **2**:451, 1861.

123. Challiès: Des tumeurs de la tunique vaginale, Thèsis (Montpellier), 1896, No. 59.

124. Balloch: Fibromata of the Tunica Vaginalis, Ann. Surg. **39**:396, 1904.

case. The boy had a keloid behind the right ear, and the tumor was considered possibly of such nature. There was no recurrence in one year.

Makins'[125] patient, a man of 27 years, had noticed multiple small nodules back of the right testicle all his life. They were painless, and felt like a bunch of grapes. They were removed, together with the tunica vaginalis at operation. The author likens them to the subserous fibromas met with in the intestines, subjacent to the peritoneum.

In five cases, the ages were 16, 18, 24, 27 and 51 years. Balloch, in his conclusions, states that, like other serous cavities, the cavity of the tunica vaginalis may be the source of fibrous growths; irritation is an important factor in their development; they arise from the subserous connective tissues and may form floating bodies; they are usually small, and are prone to fatty or myoxamatous degeneration which may involve the testicle; excision is the only recourse, and they do not tend to recur.

Rhabdomyoma: Two cases have been described and are accepted by Grote;[111] that of Neumann[126] in a child of 3½ years, and that of Rokitansky[127] in a boy of 18 years. They derive the tumors from the embryonal gubernaculum Hunteri.

Osteochondroma: A case was reported in 1863 by Barigaudin.[128] Apparently, the diagnosis was made on gross characteristics, as no microscopic examination is reported.

Sarcoma: About twelve cases of sarcomas of the tunica vaginalis have been collected which may be regarded as authentic. The earliest reference is a case reported by Home[129] and accepted as probably sarcoma by Curling,[95] in which operation was performed by Hunter in 1782. A year previously, the patient felt an uneasy sensation in the scrotum and was told that it was due to a hydrocele. The tumor grew rapidly and became very painful. At operation, a thickened tunica vaginalis was found distended with bloody fluid. The testicle was normal. The patient died several months later of abdominal metastasis.

Curling[130] cites the unusual case of Craven, in a man of 45 years with rapid swelling of the scrotum of two months' duration. The tumor and both testicles were removed. The patient died a few months later of internal disease (probably metastasis). Curling[130] and Klebs[106]

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125. Makins: Multiple Fibromata of the Tunica Vaginalis, Proc. Roy. Med. Soc., London (Surg. Sect.) **5**:155, 1911-1912.

126. Neumann: Virchows Arch. f. path. Anat. **103,** 1886.

127. Rokitansky: Ztschr. d. Gesellsch. d. Aerzte zu Wien **5,** 1849.

128. Barigaudin: Gaz. d. hôp. **36**:303, No. 76, 1863.

129. Home: Observations on Cancer, p. 125, 1805.

130. Curling: Fibroid Deposit in the Testis and Its Coverings, Tr. Path. Soc., London **20**:249, 1868-1869.

believe this to be a case of double diffuse sarcoma of the tunica vaginalis.

Klebs [106] further cites a case of Baum and one of Desgranges as authentic. The latter was reported in detail by Lorraine [131] in 1868. Among the earlier cases reported was that of Benedict [132] in 1835, which Grote [111] accepts.

Adler [133] in 1894 reported a large sarcoma of the tunica vaginalis of three weeks' duration in a boy of 19 years, and Reverdin [134] in the same year reported a case in an infant. Miyata [135] (1913) reported three cases which Schulz and Eisendrath [82] believe may be accepted. Kocher [107] (p. 186), in 1887, reported a myxosarcoma of the vaginalis in a boy of 19 years.

An unusual case is recorded by Karewski [80] of a patient of 57 years, in which the tumor weighed 19¾ pounds (8,900 gm.). A tumor in the region of the right testicle had been present since childhood. Four years before, it began to grow slowly, and during the last few months grew rapidly, the scrotum reaching to his knees, and seriously hindering locomotion. At operation, the testicle was found to be involved, as well as the epididymis and cord. The tumor resembled a large fibroid of the uterus. Clinically, the case is one of a benign fibroma undergoing malignant degeneration. The ultimate results in the case are not stated.

In Grote's [111] case, in a man of 30 years, the tumor weighed 150 gm., and was of from six to eight years' duration. Most of its growth had occurred during the last two years. There was no history of trauma. Orchidectomy was performed, and the parietal layer of the tunica vaginalis was found to consist of multiple nodules, which on microscopic examination proved to be fibrosarcoma. The testis, cord and epididymis were normal. The patient was living and well two years later.

Carcinoma: A questionable case was reported by Dudon [136] (1873) which Grote [111] regards as sarcoma. Rindone [137] (1901) has reported a tumor originating in the tunica vaginalis which he regards as a lymphangio-endothelioma.

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131. Lorraine: Coll. des Diss. Strassbourg **5**, Series 3, 1868.

132. Benedict: Rust's Magazin der Gesammten Heilkunde, 1835, p. 163.

133. Adler: Sarcome de la tunique vaginale, Semaine méd. **2**:320, 1894.

134. Reverdin: Sarcome de la tunique vaginale chez un enfant, Rev. méd. de la Suisse Rom., No. 4, 1894.

135. Miyata: Zur Kenntniss der Hodengeschwülste und die Bedeutung des Traumas für ihre Entstehung, Arch. f. klin. Chir. **101**:426, 1913.

136. Dudon: Cancer de la tunique vaginale, Bordeaux méd., 1873, p. 259.

137. Rindone: Linfangioendothelioma della vaginale, Gior. d. Ass.. napol. di med. e nat., 1901, p. 280.

TUMORS OF THE TUNICA ALBUGINEA

Fibroma.—Four authentic cases have been collected, and are presented in Table 4.

Certain other cases, such as the myoma testis of Swan [138] (1881) and Abrams [139] (1880-1882) are probably of teratomatous nature, belonging to the testis proper, and therefore are not included in Table 4.

Sarcoma.—No case of sarcoma of the tunica albuginea has been found in our perusal of the literature.

TABLE 4.—*Summary of Four Cases of Tumors of Tunica Albuginea*

Author	Year	Side	Duration	Trauma	Operation	Results	Nature of Tumor
Melchiori....	1852	Right	2 years	Present	Castration	Not stated	Pure fibroma size of hen's egg, distending tunica vaginalis
Hayward....	1871	Right	8 years	Not stated	Castration	Patient died eighth day after operation, of infection	Pure fibroma distending tunica
Lardennois and Lecene	1911	Left	Long	Hemorrhage from varicocele	Enucleation	Not stated	Fibroma, round nodule projecting from testis slightly
Boyer.....	1919	Left	12 days	Present	Castration	Not stated	Pure fibroma enveloping testis, forming mass 12×6×6 cm.; testis normal 6×3×2 cm.

CLINICAL DIFFERENTIATION AND SIGNIFICANCE OF TUMORS OF THE SPERMATIC CORD, EPIDIDYMIS AND TESTICULAR TUNICS

It is rarely possible clinically to make a nice differentiation of the type of tumor, or even in many cases to identify the swelling as a neoplasm. Efforts should be directed clinically toward the determination of two points: (1) whether or not the swelling is a tumor, and (2) whether it is benign or malignant. As regards the first point, one must bear in mind the similarity of the clinical pictures of hernias and certain tumors, such as lipomas, which usually occupy the upper part of the cord. Dermoids as well as lipomas frequently lie in the inguinal canal, and may even be reducible, and give an impulse on coughing. Hydroceles and cysts may mask a tumor or be mistaken for one. Rarely gumma or, as in Case 2, tuberculosis may be the diagnosis, when the true condition is neoplastic. Often the correct diagnosis can be arrived at only by careful correlation of facts in the history with the physical

138. Swan: Myoma Testis, Dublin J. M. Sc. **71**:179, 1881.
139. Abrams: Myoma Testis, Proc. Path. Soc., Dublin **9**:53, 1880-1882

findings. In most cases in the literature, the diagnosis has rarely been made until operation; a fact to be expected in view of the rarity of extratesticular scrotal tumors.

As regards the type of tumor, it is well to remember that with the single exception of lipomas, the most common tumors of these structures are sarcomas. It is sometimes possible to determine their site clinically by finding the cord, epididymis, or testicle identified with or separate from the mass. However, the site is of little importance from a prognostic point of view since, in any case, their course parallels that of testicular tumors as regards metastases.

TREATMENT

In view of the preponderance of malignant tumors in the spermatic cord, epididymis and testicular tunics, as compared with benign growths, it is of the utmost importance to arrive at an early diagnosis, just as in testicular tumors. In case of doubt, the exact condition should be determined by exploratory incision. For benign tumors, simple enucleation will generally suffice, but if a tumor of malignant nature is found, the patient should be subjected to the radical operation for teratoma testis. It has been found that simple castration cures only from 15 to 20 per cent. of cases of testicular tumor; whereas, a recent personal analysis of seventy-nine radical operations shows that 30 per cent. or more may be expected to be cured by the radical procedure, which consists briefly in removal of the tumor mass and the primary lymph nodes into which it drains: the retroperitoneal lumbar glands along the aorta and vena cava.

SUMMARY AND CONCLUSIONS

1. The extreme rarity of new growths in the epididymis, spermatic cord and testicular tunics, and the lack of attention accorded them, particularly in this country, emphasizes the importance of recording new cases and reviewing comprehensively those already reported.

2. The case of the spermatic cord and the two cases of epithelial neoplasm of the epididymis are reported because of their unusual features and extreme rarity.

3. The comprehensive classification of tumors of the spermatic cord, epididymis and testicular tunics is the first to be submitted.

4. A review of the literature reveals the fact that, of tumors involving these three structures, tumors of the spermatic cord are most frequent, constituting perhaps 90 per cent. or more of the entire group.

5. The relative frequency of tumors of the cord is of interest in that lipomas are most frequently met with, and sarcoma stands a close second. Dermoids, fibromas and myomas are next in order of frequency.

(*a*) Lipoma is to be differentiated from fat hernia, which is much more common, and which may contain a peritoneal sac and constitute a source of danger for the surgeon.

(*b*) Sarcoma, with the exception of lipoma, is the most frequent tumor of the cord. They represent at least 24.7 per cent. of all cord tumors. Their clinical picture is similar to that of teratoma testis, and they apparently arise frequently from benign conditions.

(*c*) Fibroma of the cord occurs about one third as often as lipoma. It apparently arises in most instances from the cord near its junction with the epididymis. Trauma is rarely mentioned as a factor in their development. Myxoma and leiomyoma are extremely rare in the cord.

(*d*) Dermoid cysts are of approximately the same frequency as fibroma. They are all of the simple type. Their origin offers difficulties in explanation.

6. As regards tumors of the epididymis, sarcoma is again the most frequently occurring neoplasm, and at least ten authentic cases have been reported. Only one case of lipoma is reported, the reason probably lying in the fact that the epididymis normally contains no fat. Six cases of leiomyomas, and four cases of carcinoma including a personal case, may be considered as authentic. No dermoids, fibromas or myxomas have been found in the literature of authentic nature.

7. Four authentic cases of fibromas of the tunica albuginea are tabulated. No sarcomas are reported. A single authentic instance of lipoma of the tunica vaginalis has been found. Approximately, thirteen cases of fibromas, two of rhabdomyomas and twelve of sarcomas of the tunica vaginalis have been reported. Epithelial neoplasms are of extreme rarity; two cases of adenomatous tumors and another reported as lymphangio-endothelioma are probably the only acceptable cases of growths of this nature.

8. Particularly significant is the relative frequency of growths of malignant nature in the spermatic cord, epididymis and testicular tunics, sarcoma constituting the type most frequently encountered in these structures as a whole, with possibly the single exception of lipomas of the cord.

9. Diagnosis not only as to benignancy or malignancy, but also as regards differentiation from other conditions, involves the careful consideration of many factors, depending on the history, clinical findings, operative findings and, not infrequently, the histologic findings. Lipomas and dermoids commonly occupy the inguinal canal while other types of tumors are generally intrascrotal.

10. Benign tumors should be awarded the treatment that they receive elsewhere. Malignant tumors, however, since they follow the course of testicular tumors, and metastasize to the same primary lymph zones retroperitoneally along the aorta and vena cava, should be accorded the same radical treatment.

A METHOD OF ESTIMATING THE EXTENSIVENESS OF LESIONS (BURNS AND SCALDS) BASED ON SURFACE AREA PROPORTIONS*

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The extensiveness of a lesion may determine its seriousness. In burns and scalds, the importance of extent of lesion has long been recognized. Sixty-three years ago, Timothy Holmes[1] said, "These injuries have been variously classified, into four divisions by Heister and Callisen, into six by Dupuytren, and various other divisions have been proposed; all of them indicating the depth of tissue implicated in the injury . . . but another, and perhaps even more important, consideration is the *extent* of the burnt surface—a matter which necessarily eludes formal classification."

It is indeed impossible, practically, to determine the actual extent of a lesion. But, what is of greater value, its extensiveness relative to the body surface can be readily estimated. To express such relationship, the lesion must be compared with factors in the body surface which (1) represent the total surface area of the body; (2) maintain a constant relation to each other and to the total body surface, and (3) must be such that the relation between the lesion and the factors can be readily divined and expressed.

Such factors are the proportions between the surface areas of members of the body and the total body surface. These members being the head, trunk, upper and lower extremities, the sum of their proportions is, obviously, 100 per cent. of the body surface. The ratio between a lesion and each member is easily judged, and that the proportions are sufficiently constant in the normal range of people can be proved. The accompanying tables show that, whereas surface areas *per se*, both total and particular, vary widely in different persons, the proportions do not so vary. Disproportioned people are few, although their possible importance in a different connection will be mentioned. Children have proportions quite different from those of adults; and this, too, is considered.

To determine mathematically the proportions of the head, trunk (including neck, male genitals and female breasts), upper extremities (not including the scapular regions) and lower extremities (including the buttocks) was the first step; to discover whether there exists a

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*From the medical service of St. John's Long Island City Hospital.

1. Holmes, Timothy: System of Surgery, Ed. 1, London, John W. Parker and Son **1**:723, 1860.

constancy of these proportions in persons of different physique was the second. The surface area measurements of Delafield and Eugene F. Du Bois [2] and of Margaret Sawyer, Richard H. Stone and Eugene F. Du Bois [3] were obtained, direct measurements being taken in preference to those calculated from formulas. These measurements were made on persons of markedly different build. From these figures, the proportions were determined. Further measurements were then made and computed by the linear method of Delafield and Eugene F. Du Bois.[4] My measurements include those of a stout man with a protuberant abdomen (J. M.), a very tall and emaciated man suffering from duodenal ulcer (W. B.), a large and well developed man (B. McK.), a short, muscular man (A. M.), and two women of markedly different

TABLE 1.—*Actual Estimation of Extensiveness of Burn in Patient (Man, Aged 45)*

Part	Degree			Totals	
	First	Second	Third		
Head (6)	...	....	...	....	3.0
Face (3)	1.5	0	0	1.5	
Scalp (3)	1.5	0	0	1.5	
Upper extremities (18)	...	....	...	....	7.5
Hands (4.5)	1.0	2.25	0	3.25	
Arms (13.5)	2.0	2.25	0	4.25	
Trunk (38)	...	....	...	....	17.0
Anterior (20)	0	0	0	....	
Posterior (18)	0	17.0	0	17.0	
Lower extremities (38)	0	0	0	....	....
Thighs (19)	...	....	..	....	
Legs (12)	...	....	..	....	
Feet (6.4)	...	....	...	....	
Total	6.0	21.5	0	....	27.5

physique. In each person, the ratio of lower extremities, trunk, upper extremities and head was then found by dividing the total surface (in square centimeters) into the surface area of each of these parts. It was considered that if these people of widely different build, whose surface areas on which the proportions were based had been found in some cases by direct measurements and in others by calculation from linear measurements, exhibited very little divergence in their proportions, the necessity of a large number of determinations on well-proportioned people would be obviated.

2. Du Bois, Delafield, and Du Bois, E. F.: Clinical Calorimetry: The Measurements of the Surface of Area of a Man, Arch. Int. Med. **15**:868 (May) 1915.

3. Sawyer, Margaret; Stone, R. H., and Du Bois, E. F.: Further Measurements of the Surface Area of Adults and Children, Arch. Int. Med. **17**:855 (June) 1916.

4. Du Bois, Delafield, and Du Bois, E. F.: Footnote 2; ibid. **17**:863 (June) 1916.

In the subjects measured by Eugene F. Du Bois et al., the average proportions were: lower extremities, 39.0 per cent.; trunk, 35.8 per cent.; upper extremities, 18.6 per cent.; head, 6.2 per cent. (Table 1). The greatest variations from these averages were: lower extremities, — 2.6; trunk, + 5.8; upper extremities, — 2.6; head, + 0.7. All variations except the last represent the divergence of one person (Mrs. McK.), who is described as "a very short and very fat woman." In my series, the average proportions were: lower extremities, 38.3 per cent.; trunk, 35.9 per cent.; upper extremities, 19.2 per cent.; head, 6.3 per cent. The greatest divergence from these averages were: lower extremities, — 4.1; trunk, + 5.9; upper extremities, — 1.3; head, ± 0.7. Here, too, the first three figures represent the divergence of

TABLE 2.—*Surface Proportions of Head, Trunk and Extremities (from Surface Area Determination by E. F. Du Bois et al)*

Subject	Age in Years	Description	Lower Extremities	Trunk	Upper Extremities	Head	Total
E. W.	26	Normal	6,696*	5,618	3,058	1,079	16,451
			40.6	34.1	18.5	6.5	99.7
E. F. D. B.	32	Normal	7,622	6,572	3,652	1,154	19,000
			40.1	34.5	19.2	6.0	99.8
G. S.	18	Emaciated, diabetic	5,920	5,003	3,028	950	14,301
			39.7	33.5	20.3	6.3	99.8
R. H. S.	21	Tall, thin	7,040	6,064	3,169	1,208	17,481
			40.2	34.6	18.1	6.9	99.8
M. S.	21	Short, stout	6,172	6,304	3,214	1,030	16,720
			36.9	37.7	19.2	6.1	99.9
R. H. H.	22	Tall, thin	7,266	6,444	3,492	1,173	18,375
			39.5	35.0	19.0	6.3	99.8
Mrs. McK.	..	Very short, very fat	6,780	7,746	2,976	1,090	18,592
			36.4	41.6	16.0	5.8	99.8
		Average, per cent.	39.0	35.8	18.6	6.2	99.7

* The upper figure is surface area in square centimeters; the lower, percentage.

one person (J. M.). The average proportions of all persons considered are: lower extremities, 38.6 per cent.; trunk, 35.8 per cent.; upper extremities, 18.9 per cent.; head, 6.2 per cent. The greatest variations from these proportions in all cases is shown in Table 3. It is particularly desirable to note that the divergence is least in those parts which constitute the smallest percentage of the total surface, so that the percentage variation is actually no greater in the trunk and lower extremity than in the upper extremity or head.

We can therefore say that, in the proportions of head, trunk, and upper and lower extremities, we have factors in the body surface which constitute the total body surface and maintain a sufficiently constant ratio between one another and the total surface.

It will be further observed that in all the adults measured the arms constitute three fourths and the hands one fourth of the upper extremities. Of the lower extremities, the thighs constitute one half; the legs, one third; the feet, one sixth; or, for ease in calculation, feet, one sixth;

legs, two sixths; thighs, three sixths. The actual numerical values expressing the ratio between these components and the total body surface are: hands, 4.5 per cent.; arms, 13.5 per cent.; feet, 6.4 per cent.; legs, 12.0 per cent.; thighs, 19.0 per cent. In special charts (Chart 1), these proportions may be noted; but there is no necessity to bear them in mind, for the more easily remembered fractions will serve.

It is not essential that we obtain or adhere to the exact average proportions, since the method of estimation cannot be precise, but must depend on individual ability to judge the relation of the lesion to the part involved. It is very desirable, however, that our classification apply without regard to the location of the lesion. Sargent and Russel [5]

TABLE 3.—*Surface Proportions of Head, Trunk and Extremities (Areas Determined by the Linear Method of E. F. and Delafield Du Bois)*

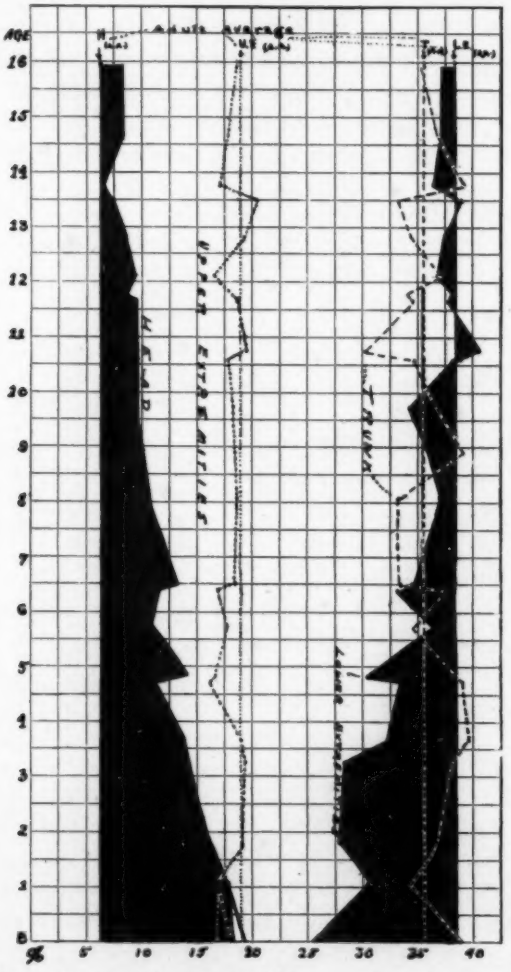
Subject	Age in Years	Description	Lower Extremities	Trunk	Upper Extremities	Head	Total
J. C.	24	Normal, thin	5,726	5,328	2,942	1,068	15,064
			38.1	35.3	19,5	7.0	99.9
Mrs. McL.	20	Normal, fleshy	6,152	5,830	2,842	1,053	15,877
			38.7	36.7	17.9	6.6	99.9
J. M.	60	Stout, protuberant abdomen	6,976	8,529	3,656	1,201	20,362
			34.2	41.8	17.9	5.8	99.7
W. B.	27	Tall, emaciated (duodenal ulcer)	6,731	6,064	3,208	1,030	17,033
			39.5	35.6	18.8	6.0	99 9
J. H.	36	Tall, thin	6,146	5,827	3,443	1,017	16,433
			37.4	35.4	20.9	6.1	99.8
W. R.	53	Tall (mentally defective)	7,372	6,308	3,947	1,062	18,689
			39.4	33.7	21.1	5.6	99.8
H. A. R.	25	Normal	6,925	5,915	3,417	1,085.5	17,342.5
			39.9	34.1	19.7	6.2	99.9
E. S.	27	Small, thin	5,587	4,849	2,579	993	14,008
			39.8	34.6	18.4	7.0	99.8
B. McK.	50	Large, well developed	7,081	6,828	3,683	1,236.5	18,828.5
			37.6	36.2	19.5	6.5	99.8
A. M.	43	Short, muscular	6,188	5,782	3,102	1,009	16,082
			38.4	35.9	19.2	6.2	99.7
		Average, per cent.	38.3	35.9	19.2	6.3	99.7

state: "Burns of the front of the chest and abdomen, and particularly of the genital and perineal region, are far more dangerous than those of the back and limbs." Whether burns of the head are especially grave is disputed. To balance the greater seriousness of burns of the anterior surface of the trunk, the third and fourth decimal places have been deducted from the average proportions of the head and extremities and added to the number expressing the proportion of the trunk. This gives the trunk a value of 38 per cent. of the body surface; and of this 20 per cent. is apportioned to the anterior surface of the trunk and 18 per cent. to the posterior surface.

The amended proportions are not difficult to remember. They are (from below upward): (1) lower extremities, 38 per cent.; (2) trunk, 38 per cent.; (3) upper extremities, 18 per cent.; (4) head, 6 per cent.

5. Sargent, Percy, and Russel, A. W.: Emergencies of General Practice, Ed. 2, London, Oxford University Press, p. 108.

If one bears these proportions in mind, estimating the extensiveness of a lesion is a very simple matter. If a burn or scald involves an entire member, it has, obviously, the same relation to the body surface as that part. If the part involved is the head, which is 6 per cent. of the body surface, the lesion is 6 per cent. If half of the head is



Age Variation of Proportions in Children: Shaded area at left, head; at right, lower extremities; dotted line, upper extremities; broken line, trunk. Straight lines represent average adult proportions.

involved, the lesion is 3 per cent. If the lesion involves the total surface of both upper extremities, it is an 18 per cent. lesion; if one extremity is involved, the lesion is 9 per cent.; if one hand is burnt on both dorsal and volar aspects, the lesion is one fourth of 9, or 2.25 per cent. A burn of the back (including the back of the neck) is 18

per cent.; of the entire anterior surface of the trunk, 20 per cent. A burn of the entire circumference of one thigh is, similarly, $38 \div 2$ (one lower extremity) $\div 2$ (one thigh), or 9.75 per cent. If less than the entire circumference is involved, an appropriate deduction must be made. A burn of the dorsal surfaces of both legs would be calculated as follows: $38 \times \frac{1}{6}$ (feet) $\times \frac{1}{2}$ (dorsum) $= 3.1$ per cent. If the lesion

TABLE 4.—*Greatest Variation from Average Adult Proportions**

Head	+0.8 (12.9%) J. C., E. S.	—0.4 (6.4%4 Mrs. McK. (D-1)†
Upper extremities	+1.0 (5.2%) J. H.	—2.9 (15.3%) Mrs. McK. (O-1)
Trunk	+6.0 (16.7%) J. M.	—2.3 (6.4%) G. S. (D-2)‡
Lower extremities	+2.0 (5.1%) E. W. (D-2)	—4.2 (10.8%) J. M.

* Average adult proportions (Tables 2 and 3): lower extremities, 38.6; trunk, 35.8; upper extremities, 18.9; head, 6.2.

† D-1, from surface area determinations of Delafield and E. F. DuBois.

‡ D-2, from surface area determinations of Margaret Sawyer, Richard H. Stone and E. F. DuBois.

TABLE 5.—*Proportions of Components of Lower Extremities*

Subject	Feet	Legs	Thighs	Total Lower Extremities	Subject	Feet	Legs	Thighs	Total Lower Extremities
E. W.	1.084	2,288	3,324	6,696	J. C.	1,071	1,819	2,836	5,726
	0.161	0.341	0.496			0.187	0.317	0.495	
E. F. D. B.	1,330	2,472	3,820	7,622	Mrs. McL.	1,071	1,894	3,187	6,152
	0.174	0.324	0.501			0.174	0.307	0.518	
G. S.	1,042	1,876	3,002	5,920	J. M.	1,135	2,157	3 684	6,976
	0.176	0.316	0.507			0.162	0.309	0.527	
R. H. S.	1,251	2,634	3,155	1,040	W. B.	1,196	2,066	3,460	6,731
	0.177	0.374	0.448			0.177	0.306	0.511	
M. S.	1,150	2,000	3,022	6,172	J. H.	1,252	1,952	2,942	6,146
	0.186	0.324	0.48[illegible]			0.263	0.317	0.478	
R. H. H.	1,158	2,396	3,712	7,266	W. R.	1.184	2,418	3,770	7,372
	0.159	0.329	0.510			0.160	0.327	0.511	
Mrs. McK.	1,124	2,156	3,500	6,780	H. A. R.	1,105	2,142	3,678	6,925
	0.165	0.417	0.516			0.159	0.309	0.531	
					E. S.	975	1,846	2,766	5,587
						0.174	0.330	0.495	
					B. McK.	1,286	2,356	3,439	7,081
						0.181	0.332	0.485	
					A. M.	1,144	2,070	2,974	6,188
						0 184	0.334	0 480	
Average	0.171	0.332	0.495		Average	0 176	0.318	0.503	
Approx. av.	1/6	1/3	1/2		Approx. av.	1/6	1/3	1/2	

involves more than one part, the lesion of each part is estimated separately, and the sum represents the percentage of the total lesion. It is well, wherever possible, to estimate separately the extensiveness of the lesion in each degree, or depth (Hebra's classification, three degrees, is proposed), as well as to note the total extensiveness:

M. R., (Table 1), admitted, June 15, 1923, injured in the explosion of a barrel of oil a half hour previous to admission, suffered a burn involving head, both upper extremities and back. The burn of the back was largest and was therefore estimated first. The back of the neck was burned, the posterior surface of the trunk to the buttocks, and part of the axillae (to a little less

than the extent of the few unharmed areas in the back). This entire lesion was of the second degree. The burn of the back was estimated as 17 per cent. The lesion on the left half of the face and scalp, involved to the first degree, was 3 per cent. The entire left hand was involved; most of the palm, to the first degree; all of the remainder, to the second degree. Almost the entire dorsum and part of the palm of the right hand were involved to the second degree. The burn of the hands was estimated thus: $18 \times \frac{1}{4} = 4.5$ (both hands) $\times \frac{3}{4}$ (–) $= 3.25$ per cent. of which 1 per cent. was first degree, 2.25 per cent. second degree. Small, discrete areas of burn were present on both arms, and on inspection it seemed that if these areas coalesced, there would be an area of burn somewhat less than two thirds of the area of one of the patient's arms. These burns were accordingly estimated as follows: $18 \times \frac{3}{4}$ (both arms) $\times \frac{1}{2}$ (one arm) $\times \frac{2}{3}$ (lesion) $= 4.25$ per cent.; of this, a little more than half (2.25 per cent.) being of the second degree depth, the remainder of this

TABLE 6.—*Proportions of Components of Upper Extremities*

Subject	Hands	Arms	Total	Subject	Hands	Arms	Total
J. C.	823	2,119	2,942	E. W.	806	2,252	3,058
	0.279	0.720			0.263	0.736	
Mrs. McL.	734	2,099	2,842	E. F. D. B.	876	2,776	3,652
	0.261	0.738			0.239	0.760	
J. M.	850	2,806	3,656	G S.	876	2,152	3,028
	0.232	0.767			0.289	0.710	
W. B.	794	2,414	3,208	R. H. S.	891	2,278	3,169
	0.247	0.752			0.281	0.718	
J. H.	932	2,511	3,443	M. S.	900	2,314	3,214
	0.270	0.729			0.280	0.719	
W. R.	986	2,959	3,947	R. H. H.	968	2,524	3,492
	0.250	0.749			0.277	0.726	
H. A. R.	825.5	2,592	3,417.5	Mrs. McK.	678	2,298	2,976
	0.241	0.758			0.227	0.772	
E. S.	685	1,894	2,579				
	0.265	0.734					
B. McK.	995	2,688	3,683				
	0.270	0.729					
A. M.	872	2,231	3,103				
	0.281	0.718					
Average	0.259	0.739		Average	0.265	0.733	
Approx. av.	¼	¾		Approx. av.	¼	¾	

lesion (2 per cent.) first degree. The entire burn was therefore: trunk 17 per cent. + head 3 per cent. + upper extremities (3.25 + 4.25) 7.5 per cent. = 27.5 per cent., of which 6 per cent. was first degree, 21.5 per cent., second degree.

The adult proportions do not hold in infants and children. The measurements made (twenty-four cases, unselected as to nutrition, development, etc.) are far too few to permit any deductions as to real proportions, or variations in the proportion, of different members, at particular ages. It seems justifiable to conclude, however, that the chief difference from adult proportions is in the increased relative size of the head and decreased relative size of the lower extremities; and that, to a lesser extent, the trunk is relatively larger in children, the upper extremities somewhat smaller in proportion. In head and lower extremities, these differences are greatest at birth and adult proportions are gradually approached, being reached at about 16 years of age. The trunk and lower extremities seem to vary less progressively (Table 6; Chart 1).

The following rule will, I believe, be found practical for estimating the proportions in children: The trunk is 40 per cent., the upper extremities 16 per cent.; for head and lower extremities, subtract age (in years) from 12 and add the remainder to the number expressing the adult proportions of the head (6). Subtract the same amount

TABLE 7.—*Proportions of Infants and Children*

Subject	Age in Years	Lower Extremities	Trunk	Upper Extremities	Head	Total
Baby S.	6 hours	551	810	379	387	2,127
		25.9	38.0	17.8	18.1	99.8
Baby M.	5 days	532	800	353.5	379	2,064.5
		25.7	38.7	17.1	18.3	99.8
A. D.	1 1/12	1,251	1,428	706	726	4,111
		30.4	34.7	17.1	17.6	99.8
A. H. (D-2)	1 9/12	1,084	1,355	700	610	3,699
		27.9	36.6	18.9	16.4	99.8
E. H.	3 3/12	1,343	1,808	913	680	4.744
		28.3	38.1	19.2	14.3	99.9
C. B.	3 8/12	1,832	2,101	931	758	5,623
		32.5	37.3	16.5	13.4	99.7
I. P.	4 9/12	2,453	2,864	1,204	832	7,353
		33.3	38.9	16.3	11.2	99.7
M. N.	4 10/12	1,626	2,045	910	746	5,327
		30.5	38.3	17.0	14.0	99.8
P. R.	5 9/12	2,830	2,691.5	1,395.5	865	7,782
		36.3	34.5	17.9	11.1	99.8
J. L.	6 5/12	2,446	2,748	1,265	854	7,313
		33.4	37.5	17.2	11.6	99.7
R. B.	6 6/12	2,342	2,269	1,223	902	6,736
		34.7	33.6	18.1	13.3	99.7
A. M.	8 1/12	3,220	2,895	1,617	888	8.620
		37.3	33.5	18.7	10.3	99.8
H. McA.	8 11/12	3,440.5	3,520	1,640	981	9,581.5
		35.9	36.7	17.1	10.2	99.9
M. F.	9 9/12	3,074	3,300	1,648	856	8 878
		34.6	37.1	18.5	9.6	99.8
M. Q.	10 7/12	3,969.5	3,564	1,827	983	10,343.5
		38.3	34.5	17.6	9.5	99.9
L. Z.	10 9/12	4,030	2,973	1,909	940	9.852
		40.9	30.1	19.3	9.5	99.8
J. O'K.	11 8/12	3,984	3,661	1,978	968.5	10,591.5
		37.6	34.5	18.6	9.1	99.8
C. A.	11 9/12	3,791	3,459	1,831	886	9,907
		38.0	34.6	18.3	8.8	99.7
S. C.	12 1/12	3.768	3,720	1,671	977	10,145
		37.1	36.7	16.4	9.6	99.8
F. R. S.	12 10/12	4,450	4,118	2,260	1,037	11,865
		37.5	34.6	19.0	8.7	99.8
F. L.	13 6/12	4,923.5	4,280	2,640	973.5	12,817
		38.4	33.3	20.5	7.5	99.7
D. M.	13 9/12	5,191	5,600	2,485	961	14,237
		36.4	39.3	17.4	6.7	99.8
M. De G.	14 8/12	3.826	3,812	1.881	903	10,422
		36.7	36.5	18.0	8.6	99.8
R. M.	15 11/12	4,792.5	4,629.5	2,406	1.047.5	12.875 5
		37.2	35.9	18.6	8.1	99.8

from the number expressing the adult proportion of the lower extremities (38). The number 12 was selected because there seems to be a variation of a little less than 1 per cent. for each year (the fraction being less with increase in age), and it seems to fit the proportions of the children that were measured. It must be borne in mind that the figure thus arrived at is the proportion of head, trunk and upper and lower extremities, as amended to the greater seriousness of burns of the anterior surface of the trunk.

There are persons, both children and adults, who vary more from average proportions than our tables would indicate. Thus, B. L., a cretin, 36 years old, measured by Delafield and Eugene F. Du Bois,[6] and reported by them to have the "general mental and physical development of a boy of 8," had the following proportions: lower extremities,

TABLE 8.—*Proportions in Infants and Children, of Components of Upper and Lower Extremities*

Name	Feet	Legs	Thighs	Total Lower Extremities	Hands	Arms	Total Upper Extremities
Baby S.	138	164	249	551	111	268	379
	0.250	0.297	0.451		0.292	0.707	
Baby M.	151	171	210	532	108.3	245.2	353.5
	0.283	0.321	0.394		0.306	0.693	
A. D.	256	438	557	1,251	220	486	706
	0.204	0.350	0.445		0.311	0.688	
A. M. (D-2)	216	340	478	1,034	214	486	700
	0.208	0.328	0.462		0.305	0.694	
E. H.	287	351	705	1,343	274	639	913
	0.213	0.261	0.524		0.300	0.699	
C. B.	392	591	849	1,832	270	661	931
	0.213	0.323	0.463		0.290	0.709	
I. P.	488	828.5	1,136.5	2,453	346	858	1,204
	0.198	0.337	0.463		0.287	0.712	
M. N.	287	516	823	1,626	249	661	910
	0.176	0.317	0.506		0.273	0.726	
P. R.	570	962	1,298	2,830	397.5	998	1,395.5
	0.201	0.339	0.458		0.284	0.715	
J. L.	397	779	1,270	2,446	394	871	1,265
	0.162	0.318	0.519		0.311	0.688	
R. B.	489	713	1,140	2,342	383	840	1,223
	0.208	0.304	0.486		0.313	0.686	
A. M.	694	1,098	1.428	3,220	456	1,161	1,617
	0.215	0.340	0.443		0.282	0.717	
H. McA.	754.5	1,175	1,511	3,440.5	512	1,128	1,640
	0.219	0.341	0.439		0.312	0.687	
M. F.	524	1,011	1,539	3,074	516	1,132	1,648
	0,170	0,328	0.500		0.313	0.686	
M. Q.	689.5	1,280	2,000	3,969.5	503	1,324	1,827
	0.173	0.322	0.503		0.275	0.724	
L. Z.	755	1,331	1,944	4,030	506	1,403	1,909
	0.187	0.330	0.482		0.265	0.734	
J. O'K.	744	1,347	1,893	3,984	539	1,439	1,978
	0.186	0.338	0.475		0.272	0.727	
C. A.	764	1,289	1,738	3,791	536	1,295	1,831
	0.201	0.340	0.458		0.292	0.707	
S. C.	774	1,273	1,721	3,768	539	1,132	1,671
	0.205	0.337	0.456		0.322	0.677	
F. R. S. (D-2)	834	1,456	2,166	4,456	640	1,620	2,260
	0.187	0.326	0.486		0.283	0.716	
F. L.	824.5	1,716	2,383	4,923.5	725	1,915	2,640
	0.167	0.348	0.484		0.274	0.725	
D. M.	929	1,766	2,496	5,191	623	1,862	2,485
	0.178	0.340	0.480		0.250	0.749	
M. De G.	756	1,300	1,770	3,826	577	1.304	1,881
	0.197	0.339	0.462		0.306	0.693	
R. M.	856.5	1,562	2,384	4,792.5	634	1,772	2,406
	0.178	0.323	0.497		0.263	0.736	

33.3 per cent.; trunk, 36.1 per cent.; upper extremities, 19.9 per cent., and head, 10.6 per cent. This (if we estimate from average adult proportions rather than from the amended proportions) is not far from what the proposed rule would yield for a child of 8 years, except for the upper extremities. Whether disproportions of various kinds

6. DuBois, Delafield, and Du Bois, E. F.: The Measurements of the Surface Area of Man, Arch. Int. Med. **15**:868 (May) 1915.

typify different forms of endocrine imbalance is a problem which at once suggests itself. Measurements in a single plane, as the relative circumferences of head and chest, have been found to be "most important measurements in children . . . adding much information in many cases of obscure diagnosis."[7] Is there not reason to suppose that proportions, easily calculated from surface areas which can be readily determined by the linear method of Delafield and Eugene F. Du Bois, will also be found of value? These matters, it is hoped, will be the subject of a subsequent report.

The actual value of determining the extensiveness of lesions will be apparent to anyone who has had to deal with burns and scalds. It lies in (1) ease in estimating and recording the extensiveness of the injury; (2) the fact that it is a means of classifying burns and scalds; and (3) prognosis.

A detailed description of the extent of a lesiaon is a lengthy procedure, at best, and even actual detailed dimensions fail to convey a clear idea of the size of the lesion. To have a definite understanding of the percentage of the total surface which is involved in a burn or scald is of importance to the physician in attendance. An easily made and readily understood record is of value, especially since these injuries frequently involve legal action.

In the study of burns, or a comparison of the progress of burns or scalds under diverse methods of treatment, it is essential that we compare lesions of approximately the same extensiveness, as well as of the same depth. The routine classification of these injuries with regard to size would, especially in institutions, be of value.

A general opinion is entertained as to what extensiveness of burn or scald (also relative to the body size) is fatal. Sluss[8] states that "mere reddening of two thirds of the cutaneous surface will almost inevitably result in death, while destruction of one third of the skin will probably produce the same result." That such opinions are founded on definite information as to the relative size of actual lesions is doubtful. It is hoped that routine use of the proposed method of estimating the extensiveness of lesions will furnish data in cases in which extensiveness has been actually estimated from relations to body proportions; and from this course will be derived a more definite knowledge of burns and scalds of varying extensiveness and depth, in adults and in children.

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7. Freeman, R. G.: Elements of Pediatrics, New York, The Macmillan Company, 1917, p. 32.

8. Sluss, J. W.: Emergency Surgery, Ed. 4 (revised), Philadelphia, P. Blakiston's Son and Co., 1917, p. 485.

SUMMARY AND CONCLUSIONS

The method of estimating the extensiveness of lesions proposed is founded on the ratio between head, trunk and upper and lower extremities, and the total body surface. This ratio, or proportion, arbitrarily corrected to the greater seriousness of lesions of the chest, abdomen and genitals, is: lower extremities, 38 per cent.; trunk, 38 per cent.; upper extremities, 18 per cent.; head, 6 per cent. In children, the proportions are different, the head and lower extremities varying considerably (and progressively) with age. To ascertain the proportions at a given age, the following rule is proposed: The trunk is 40 per cent., the upper extremities 16 per cent. For head and lower extremities, subtract age (in years) from 12 and add the remainder to the number expressing adult proportion (6) for the head. Subtract the same amount from the number expressing the adult proportion (38) for the lower extremities.

To estimate a lesion of the head, trunk, upper or lower extremities, the number expressing the proportion of that part is multiplied by the fraction expressing the relation of the lesion to the part. For ease in arriving at the latter relation, it should be borne in mind that the hand is one fourth of an upper extremity; the arm, three fourths; that a foot is one sixth; a leg, two sixths; a thigh three sixths of a lower extremity. The anterior surface of the trunk is 20 per cent.; the posterior surface, 18 per cent. The trunk includes the neck; the lower extremities include the buttocks. If more than one part is injured, the lesion of each part is estimated separately, and the sum represents the extensiveness of the total lesion. It is preferable to classify the extensiveness of the lesion in each degree.

The proportions of hands and feet are somewhat greater in children than in adults, in our measurements. These parts constitute so small a part of the total surface that, for our purpose, this difference can be disregarded.

Burns and scalds are very serious and frequently fatal accidents. In few injuries is the outcome so doubtful initially; nor does it continue to be uncertain for so long a time. If the patient recovers from an extensive burn or scald, the convalescence is long. One child, 7 years old, burned in a bonfire, remained in the St. John's Long Island City Hospital for 242 days; a woman scalded with hot soup was discharged improved after 119 days.

With some practice, the proposed method can be applied with facility. In so important a condition, it seems justifiable to spend a little time to estimate and record carefully the extensiveness of the lesion.

STUDIES OF EXOPHTHALMIC GOITER AND THE INVOLUNTARY NERVOUS SYSTEM

X. THE COURSE OF THE SUBJECTIVE AND OBJECTIVE MANIFESTATIONS IN FIFTY UNSELECTED PATIENTS OBSERVED OVER A PERIOD OF TWO YEARS, IN WHOM NO SPECIFIC THERAPEUTIC MEASURES WERE INSTITUTED ("SPONTANEOUS COURSE") *

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In January, 1921, we instituted a study of fifty unselected cases of fully developed exophthalmic goiter.[1] No specific therapeutic measures were employed "in order to determine the natural history (spontaneous course) of the disease," [2] and to establish an "index for the evaluation of therapeutic procedures." [3] From the group were excluded (*a*) patients who had thyroid enlargement without other manifestations of exophthalmic goiter,[4] and (*b*) those who, with or without thyroid enlargement, presented sympathomimetic symptoms, without significant elevation of the basal metabolism (autonomic imbalance).[5] In the group studied, we included (1) patients with a significant elevation of metabolism on repeated readings; (2) patients whose illness was sufficiently severe to warrant residence in a hospital where beds are at a great premium (two exceptions), and (3) patients from the poorest sections of the city, who were subjected to constant economic strain (one exception).

The patients were first observed in the general wards of the hospital. An attempt was made to secure for them complete physical and mental relaxation. A high caloric diet (3,000 calories) was ordered and wet packs at 75 degrees were used daily. In the beginning, daily colon irrigations were employed, but these were later discontinued. Foci of

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* From the medical service of the Mount Sinai Hospital.

1. Kessel, Leo; Hyman, H. T., and Lande, Herman: A Study of Fifty Consecutive Cases of Exophthalmic Goiter, Arch. Int. Med. **31**:433 (March) 1923.

2. Lieb, C. C.; Kessel, Leo, and Hyman, H. T.: Am. J. M. Sc. **165**:384 (March) 1923.

3. Kessel, Leo; Hyman, H. T., and Lieb, C. C.: Exophthalmic Goiter and Involuntary Nervous System; Clinical and Laboratory Study of Involuntary Nervous System, J. A. M. A. **79**:1213 (Oct. 7) 1922.

4. Kessel, Leo, and Hyman, H. T.: Am. J. M. Sc. **165**:387 (March) 1923.

5. Kessel, Leo, and Hyman, H. T.: Am. J. M. Sc. **165**:513 (April) 1923.

infection, particularly in the nose and throat, were attacked, and extirpated or drained. Phenobarbital (luminal), 1½ grains, was used as a hypnotic and syrup of ferrous iodid, from 5 to 30 minims, three times a day, was prescribed to hasten the involution of the thyroid.* There was no other routine medication. No purposeful psychotherapy was employed, but the patients were shielded, as far as possible, from psychic trauma, and attempts were made to adjust their social and economic difficulties.

After an average hospital stay of six weeks, the patients were sent to the country, and were given small tasks. In another two to six weeks, they were returned home, and permitted to resume their responsibilities gradually. They were instructed as to their disease and were warned that the condition was arrested rather than cured and the possibility of recurrence was emphasized. They were urged, in addition to regular attendance at the outpatients' department, to return at the recurrence of the slightest symptoms. The families were warned that these people must be protected, but without coddling. All the follow-up observations were made personally by us. In our presentation, we included a history of these fifty consecutive patients, irrespec-

* Since this article was written, Plummer and his associates at the Mayo Clinic have expressed the opinion that "iodin in the form of Lugol's solution nearly always causes a marked drop in the basal metabolic rate, with coincident clinical improvement in patients with exophthalmic goiter" (Boothby and Rowntree, J. Pharm. & Exper. Therap. **22**:*2*, 106). That there may be no misunderstanding of our statement with regard to our use of iodid in this series as reported above and elsewhere (Hyman, H. T.; Lande, H., and Kessel, L.: A Study of Fifty Consecutive Cases of Exophthalmic Goiter, Arch. Int. Med. **31**: 433 [March] 1923), we wish to make the following addenda: 1. Almost without exception, no patient in this series received iodid during the first month of observation and rarely within the first six weeks, during which time the greatest improvements were noted. 2. The administration of the iodids was not accompanied by any marked alteration in the rate of improvement in our experience: when benefit accompanied the exhibition of the drug, it was unusual to observe any changes other than a continuation of the amelioration of symptoms noted in the preceding weeks. Without wishing to express any final opinion as to the statements of the Mayo Clinic workers, we wish to point out that, in order to demonstrate a specific iodid effect, it should be a simple matter to administer the drug to a consecutive series and compare the results obtained with our data above, which, for the first four to six weeks, at least, may be taken as a true control series. As the iodid effect as described by these workers shows "convincing evidence," "great improvement," "material lowering of the basal metabolism," etc., even so short a period of observation should be quite sufficient to show an improvement over and above the expectancy from the spontaneous course. Should there be no clearcut improvement, however, it may be assumed that the effects were not specific, but a manifestation of the spontaneous course.

tive of end-results, and with extensive follow-up observations. When the patient could not be kept under observation, we regarded the issue as unsuccessful.

In this paper, we present the subjective and objective results at the conclusion of a period averaging twenty-five months, including all data to May 1, 1923.

I. COURSE OF THE SUBJECTIVE SYMPTOMS

In any disease, the course of the subjective symptoms is extremely difficult of presentation and interpretation. Because of the marked psychic instability, this is particularly true of exophthalmic goiter.

The subjective findings were recorded as to frequency and intensity. The intensity of the entrance symptoms was approximated by us on the relative basis of 0 to $++++$. In subsequent examinations, the intensity of the symptoms was estimated by the patient.

Two sets of symptoms are usually present in exophthalmic goiter. The first group is of indefinite duration. Their presence, we believe, points to a diathesis (autonomic imbalance) [5] upon which exophthalmic goiter is likely to develop. The second group consists of the actual presenting symptoms of the syndrome, and these differ from the first in their greater intensity and the more accurate demarcation of onset in point of time.

In the vast majority of our patients, the subjective symptoms have not entirely and completely disappeared. Residual symptoms persist and these are usually identical with the symptoms of the diathesis. The actual number of symptoms did not show great diminution, but there was a marked decrease in their intensity. This we have attempted to express numerically by a determination of the "symptom score." Each symptom was scored on the basis of 0 to $++++$, and the sum of the pluses was taken as the symptom score at each visit. At the end of three months, the symptom score fell from 100 to 31 per cent. and at the end of six and twelve months to about 18 per cent., this fall corresponding quite closely to the fall in metabolism. Nervousness, palpitation, sweating, bulging of the eyes and asthenia were responsible for the greater part of the residual symptom scores. These residual symptoms later appeared only transiently on provocation, and were usually insufficient to interfere with economic usefulness.

The course of the subjective symptoms in patients who had received specific therapy has received little attention in the literature. Specific statements could be obtained only from a report by Judd [6] from the Mayo Clinic. He compared the symptoms present in 200 patients six years after operative interference. One hundred of these patients

6. Judd, E. S.: Ann. Surg. **72**:145 (Aug.) 1920.

presented true exopthalmic goiters, and 100 so-called toxic adenomas. Residual symptoms were present in Judd's series (Charts 1 and 2). Nervousness persisted in 40, palpitation in 36, tremor in 16, asthenia in 16 and dyspnea in 28 per cent. of his patients, the actual symptoms corresponding closely to the residual symptoms in our patients. That these symptoms were insufficient to interfere economically with the patients may be inferred from the fact that Judd reports satisfactory results in 78 per cent. of the true exophthalmic series and in 88 per cent. of the toxic adenoma series. It is impossible to compare results quantitatively, because Judd's patients answered his questionnaire by letter

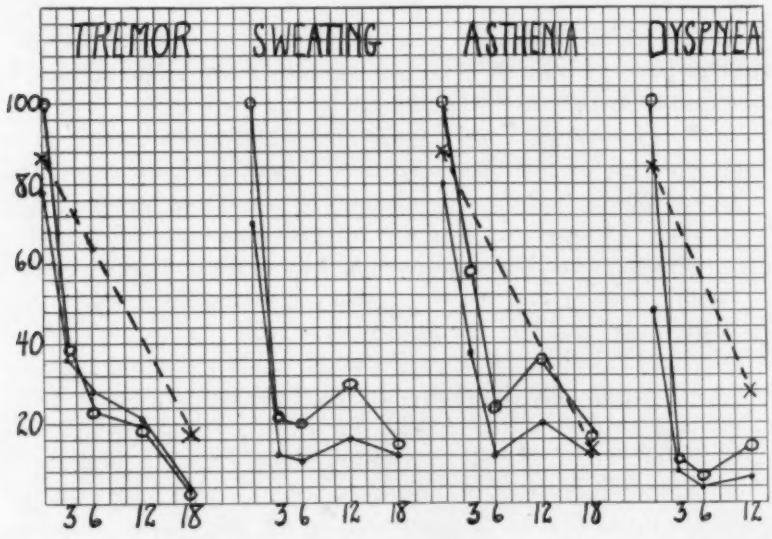

Chart 1.—The course of the subjective symptoms in exophthalmic goiter. The figures on the perpendicular in this chart and Chart 2 refer to time in months, while those on the horizontal are in terms of percentage. The solid line with rings is obtained from our patient's histories by adding the individual symptom scores on entrance and estimating the changes in intensity by comparing the scores at the times stated. The solid line with the dots also refers to our patients and indicates the actual percentage of individuals complaining of the symptom, irrespective of intensity, at the time intervals stated. The interrupted line with crosses indicates the percentage of Judd's 200 patients who presented the individual symptom on admission and after six years, irrespective of intensity.

after a lapse of six years. Our results were obtained from the patient personally at frequent intervals in the course of the first eighteen months, and coincide closely with Judd's results at the end of six years. Whether our six-year figures will be equally favorable remains to be seen.

CONCLUSIONS

1. The subjective symptoms in exophthalmic goiter may be divided into two groups: those of the diathesis (autonomic imbalance), and those of the crisis associated with the metabolic upset.

2. In fifty patients treated by "skilful neglect" over a two-year period, residual symptoms were usually present, and these, as a rule, were the symptoms of the diathesis.

3. Despite the persistence of residual symptoms, there was a marked and progressive decrease in their intensity.

4. Residual symptoms are present in patients who have had specific therapy.

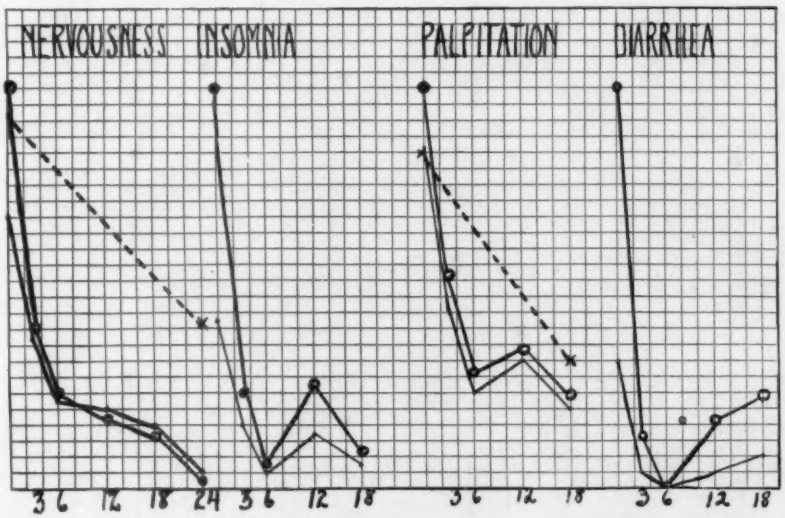

Chart 2.—The course of the subjective symptoms in exophthalmic goiter.

5. The course of the subjective symptoms in patients who received no specific therapy did not compare unfavorably with that following thyroidectomy.

II. SOCIAL AND ECONOMIC RESTITUTION

Social and economic restitution is the most important desideratum from the standpoint of the patient. Forty-two, or 83 per cent., of our fifty-one patients were economically restored. This occurred in less than four months in twenty-nine, or 57 per cent., and between four and six months in thirty-three, or 65 per cent. (Table 1).

Delayed but eventual restoration occurred in nine patients. In this group, we included all who, six months after their hospital admission, were still socially incapacitated. The delay in restoration was usually due to the continued operation of the initial exciting cause.

The economic restitution has been uninterrupted in thirty of the forty-two patients. Ten have had mild and transitory exacerbations, all of which terminated in remission within two weeks. Two suffered true recurrences of a severity paralleling the initial crisis. These patients left our institution, and sought surgical aid elsewhere. One of them died nine days after thyroidectomy, for which he had been prepared by two roentgen-ray exposures and two ligations. The other has made a striking recovery following a partial thyroidectomy.

At the end of a span of observation averaging twenty-five months, forty patients, or 79 per cent., have been economically restored, and have maintained their improvement without any appreciable recurrence of symptoms.

TABLE 1.—*Summary of Results on Social and Economic Basis*

Average hospital stay (48 patients)	6 weeks	
Average rest in country (28 patients)	5 weeks	
		Means and Holmes
Number of patients economically restored	42 or 83%	76%
Up to 4 months	29 or 57%	11%
4 to 6 months	4 or 8%	
Over 6 months	9 or 18%	
Recurrences after economic restitution:		
Severe (1 death, 1 recovery, postoperative)	2	2
Mild, transitory	10	
None	30	
Average time of total observation	25 months	
		Holmes and Means
Economic incapacitation	9 or 17%	20%
Deaths	5	
Cardiac condition	1	
Gallbladder infection	1	
Failures	2	
Delayed but eventual restitution (6 months +)	9 or 17%	32%
Infection	3	
Pneumonia	1	
Exophthalmic goiter	5	

Nine patients, or 17 per cent., were never economically restored. Of these cases, five were fatal (to be discussed later); in another, the patient, a woman, is incapacitated, owing to cardiac insufficiency from auricular fibrillation. This woman's basal metabolism fell from + 48 to + 26 per cent in one year. Still another woman is incapacitated, owing to abdominal symptoms from an infected gallbladder. Her basal metabolism fell from + 50 to + 24 per cent. in one year. Despite the fall in the metabolism and the remission of the symptoms of exophthalmic goiter, we are reporting these cases as failures, though the economic incapacitation present is due to conditions foreign to the exophthalmic goiter. The remaining two cases of this group are true failures in that the patients have been incapacitated as a direct result of the exophthalmic goiter.

Means and Holmes [7] have published roentgenotherapy data that are comparable to the data presented here. Of their forty-four patients, nine, or 20 per cent., have never been economically restored, as compared with 17 per cent. in our series. Of the thirty-five patients economically restored, seven were ambulatory. Of the thirty-seven patients who had been economically incapacitated, twenty-eight, or 76 per cent., were economically restored, as compared with 83 per cent. in our series. Of these twenty-eight, but four were restored within four months, as compared to twenty-nine of our patients, and the average

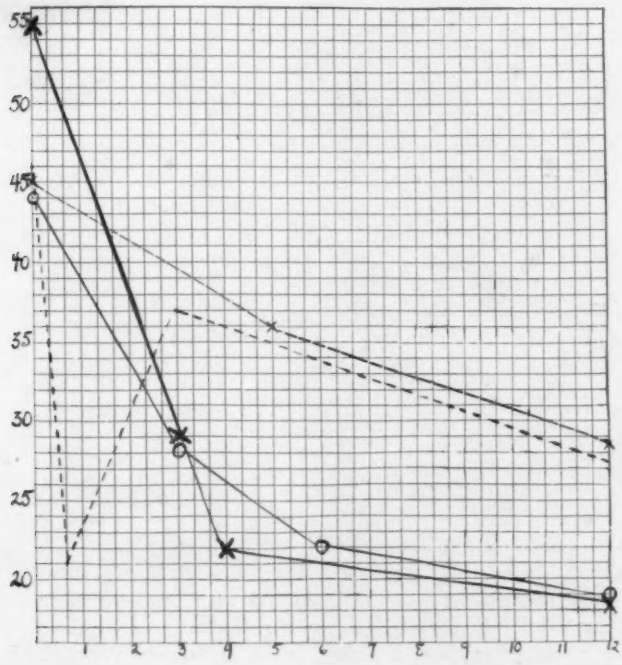

Chart 3.—Course of the basal metabolism in the first year. Solid line with crosses obtained from the Means and Holmes series recently reported, twenty-eight cases selected from forty-four treated by roentgen ray. The plain interrupted line and the crossed interrupted line are charted from the earlier observations of these workers with Aub, the former being obtained from the surgical series, the latter from another roentgen-ray series. The solid line with rings is charted from our fifty unselected patients who received no specific therapy.

time of restoration in their patients was twelve months; whereas, 65 per cent. of our patients were restored in less than six months, and our average time for restitution was less than six months. Of their patients who were economically restored, two had true recurrences sufficient to

7. Means, J. H., and Holmes, G. W.: Roentgen-Ray Treatment of Toxic Goiter, Arch. Int. Med. **31**:303 (March) 1923.

demand hospital admission and both were still economically incapacitated at the time of publication. We also report two recurrences sufficiently severe to demand hospitalization.

We have been unable to find comparable data from the surgical clinics. We did find various general statements to the effect that the restitution under surgical management is much more rapid than under medical management. In many of the surgical clinics, at least two

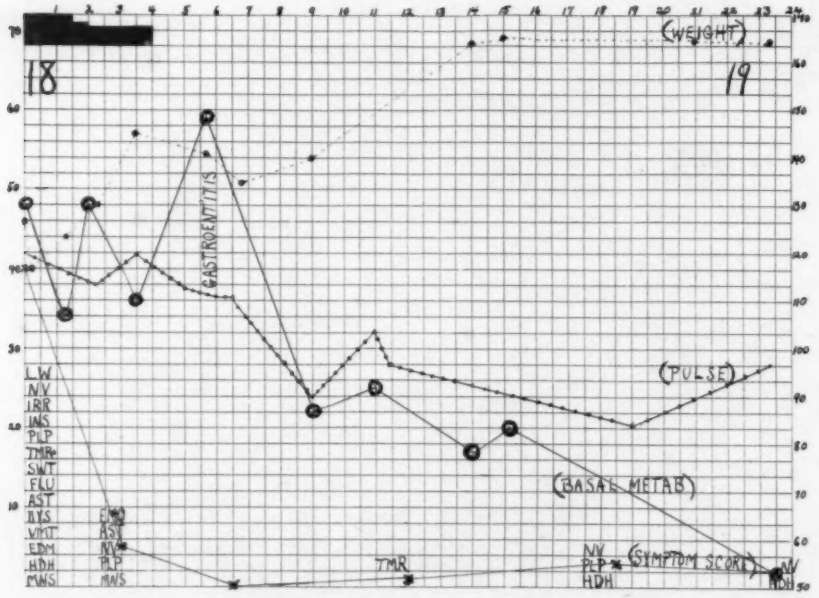

Chart 4.—Method of estimating results in individual patients (S. G., woman, aged 32, married). In this chart and Charts 5-10, the perpendicular lines denote the lapse of two weeks. The shaded area in the upper left corner represents economic incapacitation: whole shading, hospitalization; three-quarter shading, complete rest at home or in the country, and half shading, partial rest at home. The unshaded area represents the economic restitution. The large figures at the top are exophthalmometer readings and neck circumference measurements (only the first and the last are given). The ringed solid line represents the basal metabolism; the crossed solid line, the symptom score; the solid line with solid circles, the weight, and the dotted solid line, the pulse rate. The figures at the right apply to the latter two, those at the left to the former two. The actual symptoms are listed at the bottom, as a rule, and are abbreviated by the omission of vowels.

preliminary ligations at weekly intervals and a three months' rest precede thyroidectomy, and patients are instructed to rest following the operative interference. Though we could not obtain exact data, it seems extremely unlikely that economic restitution following surgical therapy can be accomplished in less than six months.

CONCLUSIONS

1. From the standpoint of the patient, economic restitution is the most important therapeutic desideratum.

2. The spontaneous course of exophthalmic goiter is toward economic restitution in the vast majority of cases (83 per cent.).

3. In thirty-three, or 65 per cent., of our fifty-one patients, this recovery took place within six months, and the general average was about six months.

4. Delayed restitution occurred in nine patients as a result of the continued operation of the original exciting cause.

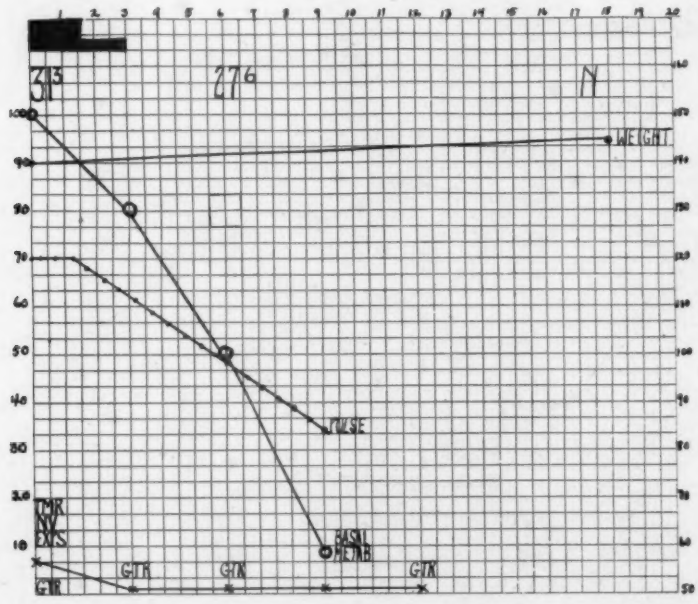

Chart 5.—Method of estimating results in individual patients (D. F., woman, aged 25, married).

5. After economic restitution, recurrence of sufficient severity to warrant readmission to the hospital occurred in but two, or 4 per cent., of the forty-two patients.

6. Complete economic incapacitation occurred in nine patients, and five of these cases were fatal.

7. These results compare more than favorably with those published from clinics in which specific therapeutic measures were instituted. They occurred with as great, if not greater rapidity, and the percentage of true recurrences is about equal.

III. OBJECTIVE MANIFESTATIONS

The course of the objective manifestations is of paramount importance to the investigator. In particular, the basal metabolism may be regarded as the best single objective index of the severity and course of the disease. In addition to observations on basal metabolism, we have measurable data concerning the exophthalmos, weight and neck circumference. We have no satisfactory data concerning the pulse rate, because of the extreme difficulty in obtaining a basal pulse.

(a) Exophthalmos (Table 2).—Complete exophthalmometer readings were obtained in twenty-eight cases. Of the patients not included

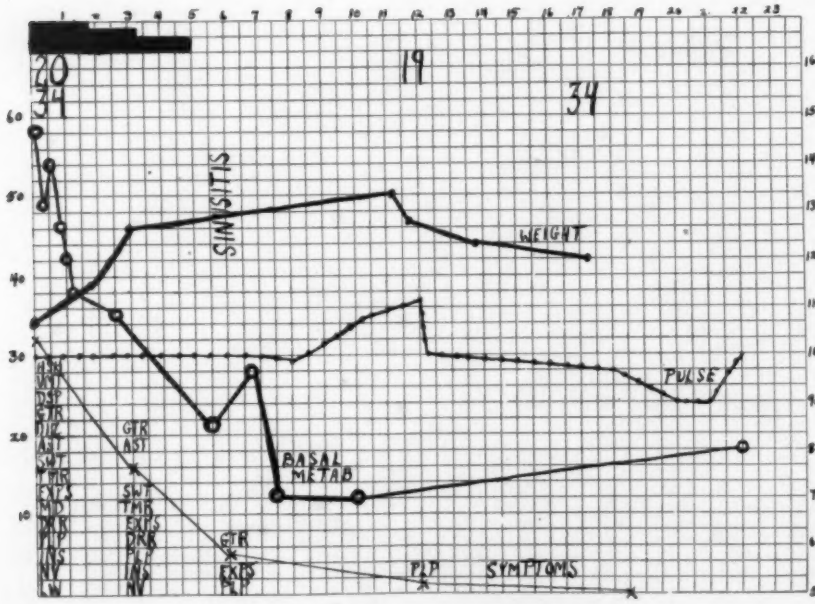

Chart 6.—Method of estimating results in individual patients (D. H., woman, aged 25, single).

above, many had normal readings, particularly the older women; some have died, and some have incomplete records for one reason or another. All complete records are included, irrespective of end-results. Three patients showed an increase in their readings and twenty-five a decrease, averaging almost 2 mm. for each fourteen months. The greatest decrease was 9 mm. in eighteen months. We have never been able to find comparable figures in cases specifically treated. Both roentgenologists and surgeons now agree, however, that the exophthalmos rarely, if ever, disappears. Hitherto, all reports concerning exophthalmos have been subjective and we strongly urge the use of the exophthalmometer.

(b) Weight (Table 2).—Forty-three of the surviving forty-five patients had an average admission weight of 118 pounds (53.5 kg.), and their average gain in weight was 16 pounds (7.3 kg.) in fourteen months, or about 1 pound (0.5 kg.) a month. Nine patients gained between 20 and 30 pounds (9 and 13.6 kg.) in this time, and four patients gained over 30 pounds. Except for the admirable report of Means and Holmes, we are unable to find other than subjective reports concerning weight. They report an average gain in weight in twenty-eight selected cases of less than 12 per cent. in fourteen months. On a percentile basis, our unselected cases show a gain close to 14 per cent. in the same time.

(c) Neck Circumference (Table 2).—The neck circumference was followed in thirty-six patients. In those cases omitted, either the neck circumference was normal, particularly in the women of the older

TABLE 2.—*Summary of Results of Course of Objective Findings*

Exophthalmos (28 patients)	
Increase	3
Decrease	25
Average	1.9 mm. in 14 mos.
Maximum	9 mm. in 18 mos.
Weight (43 patients)	
Admission (average)	118 pounds
Last (average)	134 pounds
Gain (average)	16 pounds in 14 mos.
Gain 0 to 20	27 patients
20 to 30	9 patients
30 and over	4 patients
Neck circumference (36 patients)	
Increased	2 cases
Decreased	34 cases
Average	4.5 cm. in 13 mos.

group, or the patient died or could not be traced. Of the thirty-six patients, two showed an increase and thirty-four a decrease averaging 4.5 cm. in thirteen months. While the measurements of neck circumference are notoriously unreliable, we made every effort to obtain comparable readings each time by pulling the tape as tightly as the patient would permit.

(d) Basal Metabolism.—By far the most interesting observations are those regarding the basal metabolism, for which, as in all our previous papers, we are indebted to Dr. Herman Lande. On admission, but 22 per cent. of the patients had a reading of below + 30 per cent. (Table 3). When last seen, 79 per cent. of the patients were below + 30 per cent. The increase in the number of patients falling below + 30 per cent. occurred in most part at three months, and almost entirely at the end of six months, corresponding approximately to the economic restitution. On admission, 78 per cent. of the patients were above + 30 per cent. At their last observation, but 21 per cent. were above + 30 per cent. The

average admission metabolism was plus 44 per cent. At three months it had fallen to + 28 per cent.; at six months, to + 22 per cent., and at the end of one year, to + 19 per cent. (Chart 3).

Comparable metabolic figures are difficult to obtain in literature for the following reasons: (1) end-results are not given; (2) as a rule, only selected cases are presented, and (3) bad results may not be included. The most complete figures which we have been able to obtain were published by Means and Aub [8] and Means and Holmes.[7] In the Means and Aub series, the average admission metabolism of the surgical patient was + 46 per cent. After operation, there was a rapid fall to + 21 per cent.; then a rise to a level which, at the end of three months, almost equaled the admission level. The rise was then followed by a gradual decline; and at three, six and twelve months, the surgical figures were + 35, + 33 and + 27 per cent., as opposed to our + 28, + 22 and + 19 per cent., respectively (Chart 3). In the roentgen-ray series of Means and Aub for 1919, the entrance metabolism of the

TABLE 3.—*Basal Metabolism Rates (Percentage)*

Age, Years	On Admission	At 3 Months	At 6 Months	At 12 Months	Last
Over 70	4	3	0	0	0
60 to 70	10	3	0	0	5
50 to 60	20	0	3	0	0
40 to 50	24	17	3	3	11
30 to 40	20	19	19	10	5
20 to 30	14	21	29	27	21
15 to 20	6 |22	21 |57	17 |75	37 |87	32 |79
0 to 15	2	15	29	23	26
Number of patients	50	46	37	30	46

roentgen-ray group was + 60 per cent., and at the end of thirteen months, + 38 per cent. In order that the figures may compare with those of their own surgical patients and our patients, all of whom had an initial metabolism of approximately + 45 per cent., we have taken the liberty of reducing their roentgen-ray figures for charting purposes by 45/60 in all instances. The results will be seen in Chart 3. On this basis, the results in the surgical and roentgen-ray group reported by these authors, with the exception of the initial transitory drop following thyroidectomy, did not vary more than 2 per cent., while our patients show a slightly more rapid and greater percentile fall in their metabolism.

In a recent series, Means and Holmes reported twenty-eight selected patients. This group of twenty-eight had been chosen from forty-four patients, of whom sixteen were reported as showing unfavorable results. The initial metabolism in this group was + 54 per cent. At the end

8. Means, J. H., and Aub, J. C.: Basal Metabolism in Exophthalmic Goiter, Arch. Int. Med. **24**:645 (Nov.) 1919; Goiter, J. A. M. A. **69**:33 (July 7) 1917.

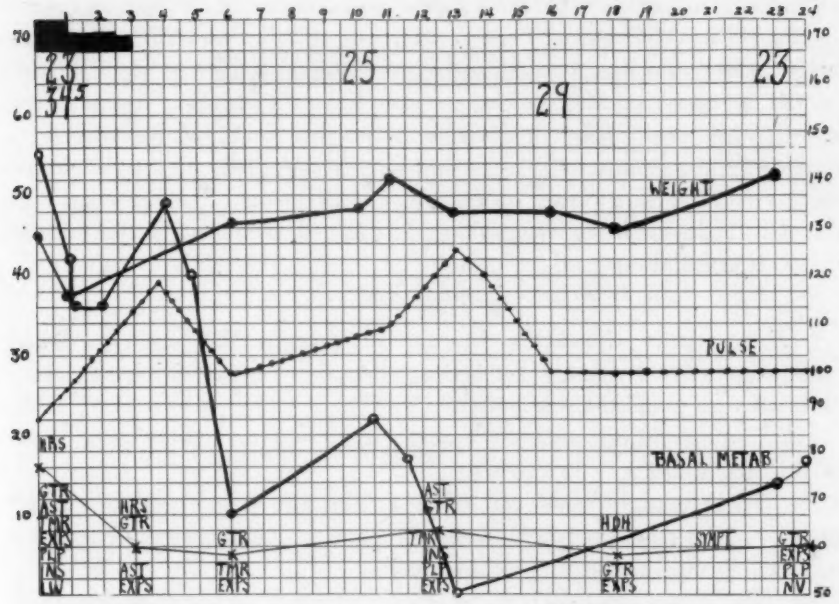

Chart 7.—Method of estimating results in individual patients (E. K., woman, aged 23, single).

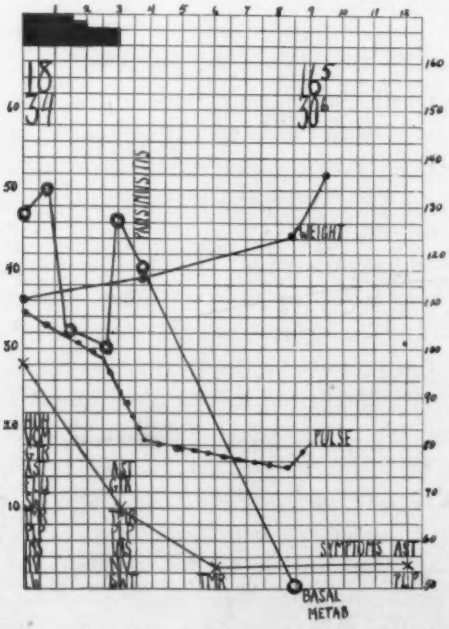

Chart 8.—Method of estimating results in individual patients (I. K., woman, aged 38, married).

of three, four, six and twelve months, respectively, these readings were + 29, + 22, + 22 and + 19 per cent., respectively (Chart 3). In other words, their patients, who started at a metabolic rate 9 per cent. higher on the average than that of our patients, reached a similar figure at the end of one year. When it is remembered that our cases included fifty that were consecutive and unselected, and that their figures included twenty-eight selected cases of a group of forty-four, it is apparent that there is little evidence from these figures of the specific therapeutic value of irradiation.

CONCLUSIONS

1. In patients who received no specific therapy, there was a marked and progressive tendency for the amelioration of the objective manifestations of exophthalmic goiter.

2. The exophthalmos and the neck circumference tended to decrease in the vast majority of patients.

3. There was a tendency to gain weight, which in these unselected patients compared favorably with the gain in weight in patients who received specific therapy (roentgen ray).

4. The basal metabolism in the first year tended to decrease progressively.

5. A graph plotted from the average figures of our untreated patients compared favorably with the graphs obtained in patients treated by roentgen ray and surgery.

IV. ANALYSIS OF BAD RESULTS

In their paper of March, 1923, Means and Holmes declare that "It is not permissible deliberately to withhold treatment from a group of patients with exophthalmic goiter for the sole purpose of accumulating scientific facts." In view of this statement, we feel that it is necessary to analyze our fatal cases.

In all, six deaths have occurred. The last death occurred in another institution, nine days following thyroidectomy. Would this man have been a better risk for the surgeons at the time when he was originally seen by us? To this question no answer can be given. In our defense, we will say that this patient was able to carry on difficult work for one year after leaving our institution, and that the fatal outcome was preceded by overwork, worry and an attack of tonsillitis. The five other deaths occurred before economic restoration. One patient died of a bleeding cancer of the stomach. One patient, after entering a period of remission, was seized with headaches and convulsions, in which she died, with the pathologic findings of status lymphaticus. Four years previously, she had had a thyroidectomy in Russia. It scarcely seems possible that any further specific therapeutic endeavor

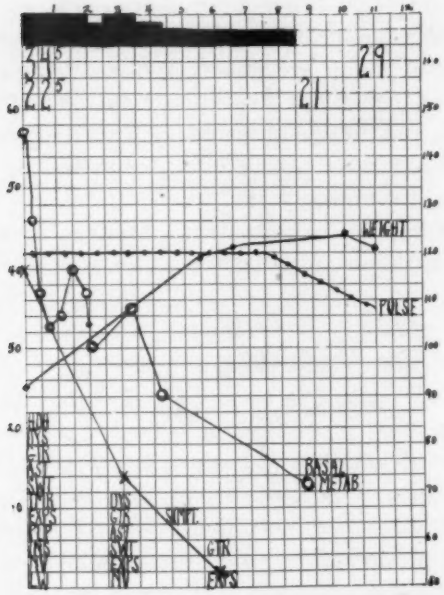

Chart 9.—Method of estimating results in individual patients (L. M., girl, aged 17).

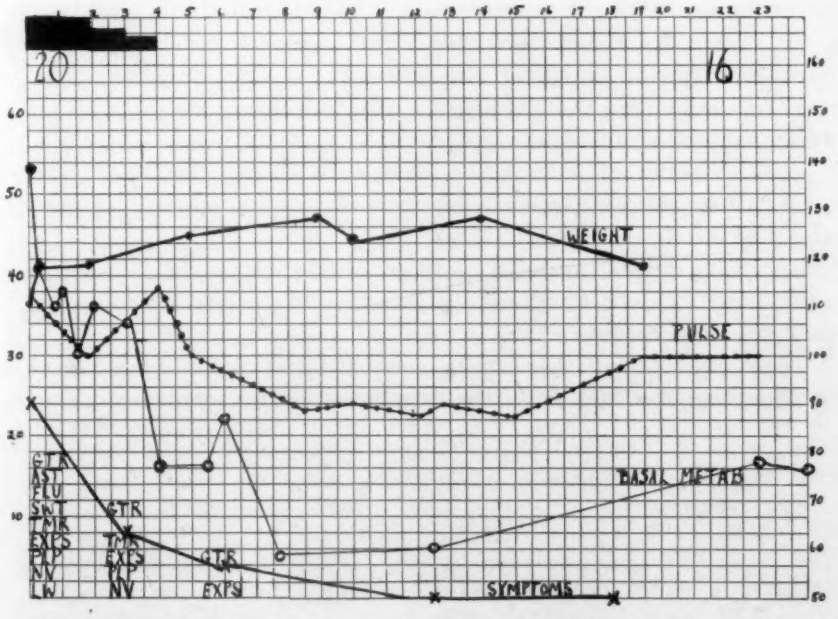

Chart 10.—Method of estimating results in individual patients (M. N., woman, aged 26, single).

relative to the thyroid would have cured her diathesis. One patient died of a generalized infection following pyelitis, after entering a remission of the exophthalmic goiter. Two patients died as a result of febrile psychoses. One of these we observed for a single day, as it was impossible to keep her in our institution; and the other was regarded as an unfavorable risk by the surgeons, and refused operation. Therefore, we cannot, in justice to ourselves, concede that our neglect has been injurious in these fatal cases.

In the four cases that we regarded as failures, the two patients who still suffer as a result of exophthalmic goiter are women of 57 and 62, respectively, and our surgeons did not regard them as safe operative risks. In the other two cases of failure, the patients are not incapacitated as a result of the exophthalmic goiter.

CONCLUSIONS

1. Subjectively, on a basis of economic restitution, and on the basis of objective findings, it is fair to say that, in the vast majority of patients with exophthalmic goiter, there was a marked and progressively increasing tendency toward "spontaneous" recovery.

2. Recovery was not complete in the sense of cure, but was marked by the persistence of residual subjective symptoms. These residual symptoms did not interfere with economic restitution.

3. In at least the first two years of the remissions, the occurrence of severe incapacitating exacerbations was infrequent.

4. These results of "skilful neglect" compare favorably with the results of specific therapeutic measures.

5. In order that the efficacy of a specific therapeutic procedure may be demonstrated, the following postulates must be met:

(*a*) A series of consecutive cases must be reported.

(*b*) The diagnosis must be confirmed by a continuous and marked elevation of the basal metabolism.

(*c*) The results must be collected on the basis of (1) subjective symptoms, (2) economic restitution and (3) objective findings, particularly basal metabolism.

(*d*) The specific therapeutic measure must result in a clear-cut amelioration over and above the expectancy in the spontaneous course.

ARTERIAL CIRCULATION OF THYROID ADENOMAS *

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AND

GRANVILLE S. DELAMERE, M.D.

SAN FRANCISCO

In the preparation of the present paper, the literature proved of little value. It contained nothing about the circulation of thyroid adenomas, so we were compelled to limit ourselves to the literature on the circulation of the normal thyroid, which is decidedly meager.

The considerable difference of opinion about the minuter details is striking. Two schools have grown up, a French and a German, the first led by Testut, Poirier, Bernard and Thane (quoted by Landström [1]), generally claiming the presence of anastomosis between the thyroid arteries; the second, represented by Kopsch, Von Eiselsberg, Hürtle and Jaeger-Luroth (quoted by Landström [1]), maintaining that thyroid arteries are end arteries, or that the anastomosing vessels are only capillaries.

Landström [1] and Streckeisen,[2] by their injections, demonstrated clearly that anastomoses were present on the surface of the glands, not only between arteries of the same side but also between those of opposite sides. Landström was convinced that anastomoses were present within the gland, but was unable to verify his conviction. In 1909, Major [3] proved the existence of anastomoses between the superior and inferior thyroid arteries on the same side, but no demonstrable definite arterial anastomoses beneath the surface of the gland.

Kohlrausch [4] (1853) found the thyroid follicles surrounded by a rich capillary network. A. Wölfler [5] saw this same network of capillaries surrounding each follicle, and also twigs running from the blood vessels to the follicles, but studied no further. Flint [6] (1903), who worked with digested specimens, stated that the blood vessels with their

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* From the Surgical Pathological Laboratory, Department of Surgery, University of California.

1. Landström: Dissertation, Stockholm, 1907.

2. Streckeisen: Beiträge zur Morphologie der Schilddrüse, Virchows Arch. f. path. Anat. **103,** 1886, pp. 131-186.

3. Major, Ralph: Studies on the Vascular System of the Thyroid Gland, Am. J. Anat., 1909.

4. Kohlrausch: Beiträge zur Kenntnis der Schilddrüse, Müller's Arch., 1853.

5. Wölfler, A.: Bau und Entwicklung der Schilddrüse, Berlin, 1880.

6. Flint: Note on the Structure of the Thyroid Gland, Bull. Johns Hopkins Hosp., 1903.

accompanying connective tissue make up the densest portion of the supporting framework; sometimes a suggestion of the lobular arrangement is given by these vessels as they ramify in the substance of the gland, but close focusing always reveals their nature. Small arterioles, venules and capillaries can be made out in the interfollicular framework or on membranes which embrace the follicles.

In the depths of the human thyroid (Major, 1909 [3]), there are but few large arteries. The branching of the large arteries takes place in the majority of instances on the surface of the gland, smaller branches being sent within. There is a definite system of vascular units which repeat themselves with more or less consistency throughout the entire organ, and these units correspond closely to the structural units. The smallest unit present, the follicular, is made up of the follicular network with its own artery and vein, and corresponds to the histologic unit of the individual follicle. The next largest unit is the lobular, composed of (1) arteries running over the clumps of follicles having as their distinct branches the follicular arteries, and (2) the arteries passing between the lobules. This unit corresponds to the structural unit of the lobule. The third unit, which Major calls the lobar unit, is formed by the arteries surrounding collections of lobules or lobes (microscopic). Lastly, there are the branches of the thyroid arteries, which ramify over the surface of the gland.

For our purpose, we used both single and multiple adenomas of the thyroid gland, surgical specimens removed by one of us (W. I. T.) at the University of California Hospital. It would be well to state here that, with these surgical specimens, perfect injections were not obtainable, because of the unpreventable severing of some of the capsular vessels, or even the occasional rupture of the capsule at operation. To overcome this, it was necessary to run distilled water through the arteries and then ligate all points of leakage. This proved to be a not too serious handicap because of the rich capsular anastomosis; yet on account of it certain small portions of the specimens were frequently not well injected. The technic was simple. Both arteries and veins were injected. Satisfactory injection was more difficult in the veins than in the arteries, owing to the greater friability of the arteries. India ink (Higgins) injections were made with a Luer syringe, the ink diluted to 50 per cent. with distilled water, in an attempt to obtain an injection material of very fine suspension. With this solution, complete injections were readily made, enough remaining within the capillaries to give a complete capillary picture.

In other specimens, a mixture of gelatin (10 gm.), bismuth carbonate (80 gm.) and sufficient water to make the solution fairly thin was injected under continuous air pressure equal to 250 mm. of

mercury; or a celloidin, camphor and acetone[7] mixture was injected under continuous air pressure, followed by digestion of the tissues with 75 per cent. commercial hydrochloric acid, thus leaving a cast of the circulatory tree. With the latter material, it was necessary to inject a very thin solution under pressure of 250 mm. of mercury, followed by the injection of a thick solution under pressure of from 25 to 50 mm. of mercury over a period of twelve hours. Thus, the vessels received a continuous supply of the injection material as the acetone diffused through the tissues, insuring a solid cast of the vessels, and not a mere shell.

Following the bismuth-gelatin injection, stereoroentgenograms were made of the mass as a whole. The adenoma was then sectioned at various levels by parallel incisions, and stereoroentgenograms taken of these sections. In this way, the detail seen in the single picture could be traced more easily. The stereoroentgenograms were photographed and mounted stereoscopically. Then the old-fashioned, plush-trimmed stereoscope was called into use, and by its means we were able to study the details at greater convenience. Microscopic sections taken at representative places were stained by hematoxylin-eosin, van Gieson's muscle and connective tissue, and Weigert's elastic tissue methods. The india ink specimens were stained only with hematoxylin-eosin.

STUDY OF THE GELATIN-BISMUTH SPECIMENS

A rich anastomosis (Fig. 1 *A*) exists between the vessels in the capsule of the adenoma. In the single adenoma, it was necessary to make an injection into only one of the larger capsular arteries to have all the others readily filled. Figure 1 shows well the single artery used for the injection of a single adenoma.

Anastomoses are present between the vessels supplying the various adenomas of an adenomatous mass. This was markedly apparent when such a mass was injected in the following manner: Four cannulas were inserted into the four largest arteries within the portion of the thyroid capsule removed with the specimen, and injection into one of them was started. It became necessary to tie off the three arteries as the injection material was being returned through them. On dissection of this same mass, five well injected adenomas were revealed (Fig. 2). Invariably one, but never more than two, of the smallest adenomas showed very poor injection.

The question arises as to whether this is due to the injection material not reaching the tumors or whether the tumors lack abundant arterial supply. No attempt is made to answer this, though it is

7. Thick solution: acetone, 500 c.c.; camphor, 50 gm.; celloidin, 75 gm.; thin solution: acetone, 600 c.c.; camphor, 20 gm.; celloidin, 30 gm.

probable that the arterial supply is deficient, since most of these poorly injected adenomas show degeneration, and often calcification.

The capsular vessels, at irregular intervals, give off many penetrating arteries, varying from very large branches to mere branching twigs. Generally, these penetrating arteries appear to enter the adenoma directly, following, roughly, a radial course. This is especially clear in the study of the small adenomas (Fig. 2). In the large adenoma, this radial tendency is followed for a greater or less distance by the larger vessels, and quite persistently by the smaller ones. Occasionally, arteries are seen bending and taking a course more or less parallel

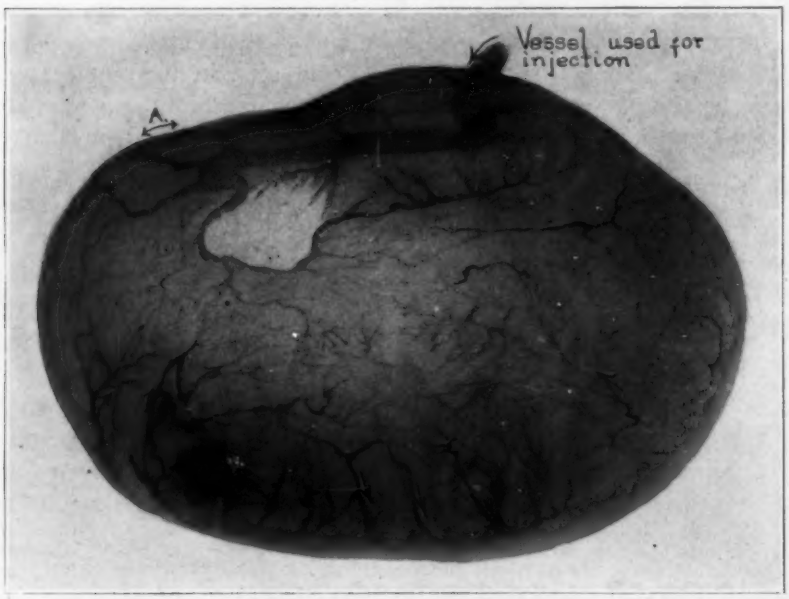

Fig. 1.—Diagrammatic drawing of stereoroentgenogram of a single adenoma injected with bismuth-gelatin mixture. The single vessel used for injection is well shown; *A*, many anastomoses between capsular vessels.

to the capsule of the tumor before assuming the radial direction. Branching occurs frequently and without any apparent order or sequence (Fig. 3).

It is quite a common thing to see a large trunk that is buried deep in the adenoma send off numerous small twigs radially from the main trunk in all directions, the twigs themselves giving off many finer branches. In the midst of this fine network, the main trunk may give off a large branch or may divide into two or more comparatively heavy trunks. Following these branches, one is impressed with the extreme vascularity of the tumor and the frequent appearance as of a dense

bush or shrub, and comes to the conclusion that these vessels are end arteries (Fig. 3). This, however, becomes doubtful when, in tracing some of the larger branches, one seems to make out fairly frequent anastomoses between these vessels. Study of the digested specimens must settle this point.

Whenever there is any degeneration within the adenoma, there is a pronounced infiltration of the injection material into these areas, as though the vessels had already been destroyed or so weakened that they could not stand the injection.

Fig. 2.—Diagrammatic drawing of stereoroentgenogram of one half of one of the five adenomas dissected from a multiple adenomatous mass after injection through one artery with the bismuth-gelatin mixture. The distinct radial tendency of the penetrating arteries is evident.

STUDY OF THE DIGESTED SPECIMENS

These specimens are the most difficult to obtain satisfactorily, because, in order to obtain a good injection, there must be no leakage in the arterial system. It took several attempts before there were enough fairly good specimens to give a clear picture of the arterial tree. Here, as in the other experiments, only one artery was injected.

Again the conclusion as to the rich capsular anastomoses is verified. These anastomoses exist between vessels of all sizes. The

penetrating branches given off by the capsular arteries are numerous and vary greatly in size. The smaller show exceedingly well the tendency to a radial course. Frequently, one of these smaller vessels can be followed for a distance of from 1.2 to 1.9 cm., running straight into the tumor. The larger vessels display this same tendency, but to a less marked degree, on account of the many large and small branchings.

The myriad vessels give a confusedly intricate mass, and it is only by carefully tracing the trunks with a magnifying glass and removing some of the outer vessels that any detail can be definitely worked out. This maze is dependent not so much on the number of vessels pene-

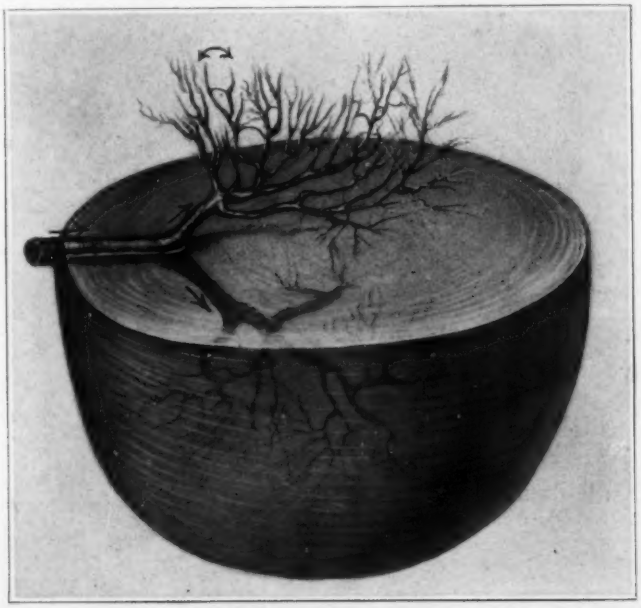

Fig. 3.—Diagrammatic composite drawing to represent the picture found in a digested specimen (a) after injection with an acetone-camphor-celloidin mixture; (b) stereoroentgenogram after injection with a bismuth mixture. Anastomoses between vessels, with marked branching ot vessels, are evident.

trating the tumor from the capsular arteries as on the frequent branchings and subdivisions which these vessels undergo at random within the adenoma.

Varying sized masses of injection material are discovered in the depths of the adenoma, due, no doubt, to the infiltration into degenerated areas.

This series of specimens proves that there are rich, easily demonstrable anastomoses between the arteries of all sizes within the depth of the tumor (Fig. 3). Arteries rising from capsular arteries in

one area anastomose with branches of capsular arteries in remote areas. Some arteries penetrate far into the tumor and there anastomose with similar neighboring arteries, forming a deep loop, the ends of which unite with two separate capsular arteries. From these loops, branches run out in all directions. This occurs with equal frequency through all portions of the adenoma.

STUDY OF THE MICROSCOPIC SECTIONS

Here again the extreme vascularity of these tumors is apparent. Numerous arteries of all sizes, some macroscopic, ramify in all direc-

Fig. 4.—Microscopic drawing of macroscopic artery found deep in adenoma after injection with bismuth-gelatin mixture. Weigert's elastic tissue stain was employed. *A*, well formed elastica of intima; *B*, elastica, very much frayed out. In this area, the elastica of the intima is not made out as such.

tions, without pattern formation or regularity. In these sections, many off-shoots from the capsular arteries make their way through the capsule obliquely and then assume the radial tendency, a fact not brought out in the other preparations. Others penetrate directly into the tumor. The branchings are irregular and numerous, often a large artery dividing into two or more vessels of approximately equal size.

The structure of these vessels varies considerably in the different tumors and different sections studied. With the hematoxylin and eosin stain, the large vessels frequently display walls comparatively very thin; on the other hand, some of the smaller vessels are relatively thick walled. If care had not been taken at the time of injection to determine whether artery or vein was being injected, some of these large, thin-

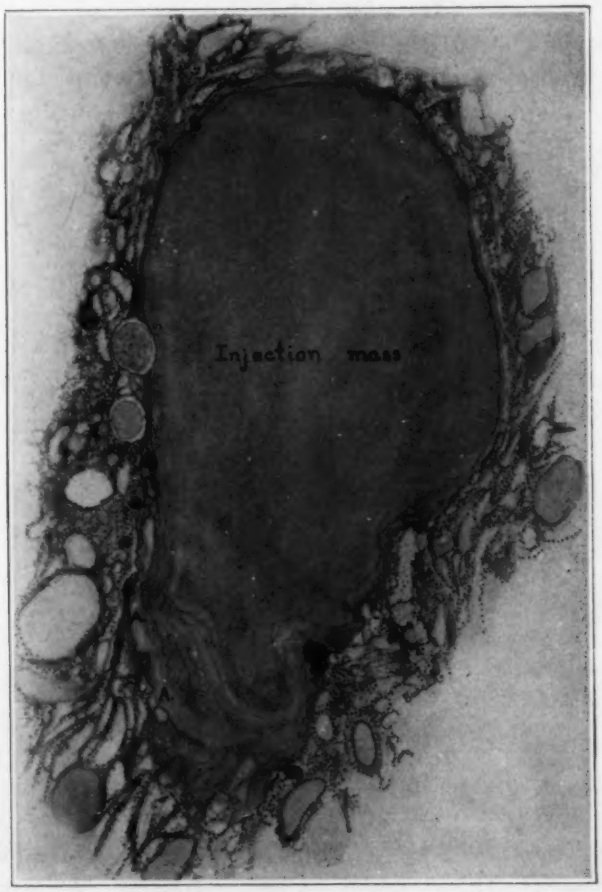

Fig. 5.—Microscopic drawing of macroscopic artery found deep in adenoma after bismuth-gelatin injection, with van Gieson's satin. *A*, Musculature; *B*, connective tissue.

walled vessels would certainly have confused the picture. No injection material has gone over into the veins, because no capillary injection with this material can be made out, as with the india ink solution of the last series of experiments. The endothelial lining is always discovered intact.

With differential stains, the largest arteries always show the wavy inner elastic layer of the intima, though often very poorly formed (Fig. 4*B*). The smaller the arteries become, the less distinct this elastic layer, until it is not demonstrable as such. In the layers corresponding to the media, fine strands of elastic tissue are woven in and

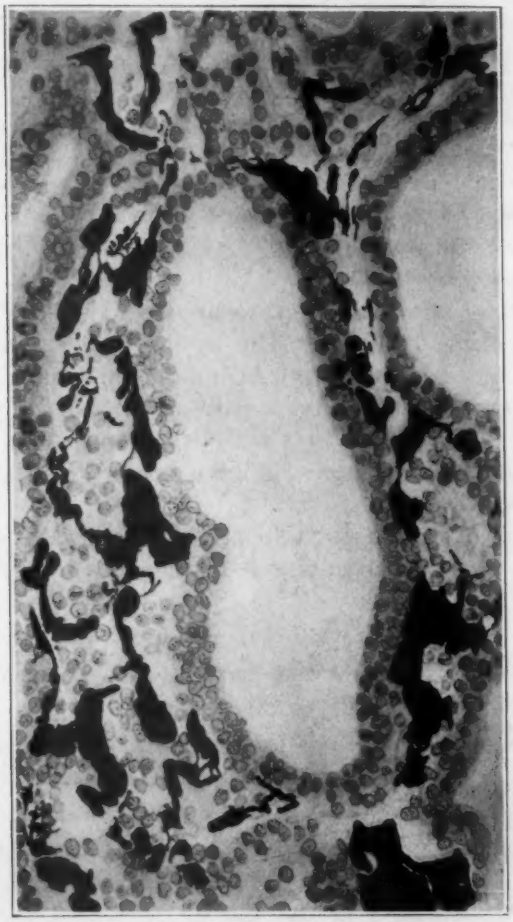

Fig. 6.—Microscopic drawing of adenoma after india ink injection. The injected vessels are black. The rich capillary network is practically the same as that pictured by Major in the normal thyroid.

out among the other tissue. These fibers persist even in many of the smaller arteries, where the inner layer cannot be made out.

The musculature is the most variable of the tissue. In many of the larger arteries, it is well formed and abundant. As the arteries become smaller, it disappears rapidly, until none is left. It is not at all uncommon to find a fairly large artery with no musculature, or at most a

few very fine fibers, while some of the smaller arteries show a much better musculature (Fig. 5).

The connective tissue element is always present, and in many cases is the chief supporting structure of the arterial wall. Its density varies considerably but seems to have no necessary relationship to the size of the vessels. Occasionally, a large thick-walled artery, which one expects to contain all the tissue elements, proves on differential staining to be made up of practically solid connective tissue, with perhaps a few poorly formed fibers of muscle and some elastic tissue. The large thin-walled arteries mentioned above show nothing but connective tissue, with a few scattered muscle fibers (Fig 5). The adventitia as such is not definitely made out, the stroma of the gland apparently taking its place (Fig. 5). With such delicate thin-walled arteries as these, one does not wonder at the frequency of hemorrhagic degeneration in these tumors.

The capillary distribution is easily ascertained in the india-ink injection specimens (Fig. 6). The picture is the same whether the adenoma is of the adult type with high differentiation of cells or of the proliferating type with slight cellular differentiation. In every instance, each alveolus is surrounded by a complete fine capillary network. On close study, this capillary network forms a weblike structure enclosing the numerous, closely placed alveoli. These capillaries vary in size. Some are almost large enough to be called arterioles. Between the capillary beds of neighboring alveoli, anastomoses are evident.

CONCLUSIONS

1. Adenomas of the thyroid have a rich anastomosis between capsular vessels of all sizes.

2. There is an abundant anastomosis between the vessels supplying the different adenomas of a multiple adenomatous mass.

3. Many arteries, macroscopic and microscopic, penetrate deeply into the substance of the adenoma from these capsular vessels.

4. The penetrating arteries have, in general, a radial tendency in their course, shown best in the smaller adenomas and the smaller arteries of the large adenomas.

5. In the substance of the adenomas, there is an extremely rich arterial supply, the vessels of which give off great numbers of branches without any apparent pattern formation.

6. There are easily demonstrable anastomoses between the arteries within the adenoma, between arteries of all sizes, and in all portions of the tumor.

7. The walls of the largest vessels show essentially a normal microscopic picture.

8. There are many large vessels whose walls show only a very thin connective tissue layer with a small amount of muscle fibers.

9. The musculature is the most variable element in the walls. Occasionally, in some of the larger vessels there is only a mere scrap remaining in one portion of the wall.

10. The elastic tissue is more constantly present than the muscle, but in some quite large vessels the inner elastic coat of the intima is often very poorly formed or partially absent.

11. The connective tissue is always present but is surprisingly thin in many of the larger vessels. No adventitia as such is definitely made out, the connective tissue stroma of the gland taking its place.

12. The endothelium is always present and is well preserved.

THE IMMEDIATE EFFECT OF SUBTOTAL THYROIDECTOMY IN TOXIC GOITER

DAILY BASAL METABOLISM AND PULSE OBSERVATIONS *

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Studies in which the basal metabolism is utilized as a quantitative index of the degree of intoxication in cases of toxic goiter have been reported from the thyroid clinic of the Massachusetts General Hospital, on the results obtained from the use of various therapeutic procedures commonly employed in these conditions. These have included the effect of rest, of quinin hydrobromate and of roentgen rays, and the later effects of surgical treatment.[1]

It is generally recognized that the clinical improvement following successful subtotal thyroidectomy is a relatively rapid one. The purpose of the present paper is to express this improvement precisely by means of daily basal metabolism and pulse rate curves, and thus to show the actual rate of detoxication in quantitative terms.

In the literature are numerous references to the ultimate effect of various surgical procedures on the course of the disease using basal metabolism and pulse as measures of intoxication. The earliest immediate postoperative metabolism observation we have found reported is that by Sturgis,[2] one hour after a hemithyroidectomy. Boothby[3] and

* From the thyroid clinic, surgical services, and medical laboratory of the Massachusetts General Hospital; aided in part by a gift from Dr. William Norton Bullard.

1. Means, J. H.: Studies of the Basal Metabolism in Disease and Their Importance in Clinical Medicine, Boston M. & S. J. **174**:864 (June 15) 1916. Means, J. H., and Aub, J. C.: Study of Exophthalmic Goiter from the Point of View of Basal Metabolism, J. A. M. A. **69**:33 (July 7) 1917. Means, J. H., and Aub, J. C.: Basal Metabolism in Exophthalmic Goiter, Arch. Int. Med. **24**:645 (Nov.) 1919. Means, J. H., and Holmes, G. W.: Further Observations on the Roentgen-Ray Treatment of Toxic Goiter, Arch. Int. Med. **31**:303 (March) 1923. Richardson, E. P.: Relative Value of Surgery and Roentgen Ray in the Treatment of Hyperthyroidism, J. A. M. A. **80**:820-825 (March 24) 1923. Porter, C. A.: Analysis of My End-Results in Thyroid Surgery, Surg., Gynec. & Obst. **36**:621-640 (May) 1923.

2. Sturgis, C. C.: Observations on One Hundred and Ninety-Two Consecutive Days of the Basal Metabolism, Food Intake, Pulse Rate, and Body Weight in a Patient with Exophthalmic Goiter, Arch. Int. Med. **32**:50 (July) 1923.

3. Boothby, W. M.: The Basal Metabolic Rate in Hyperthyroidism, Collected Papers of the Mayo Clinic, 1921, p. 469.

Eberts [4] each report one observation on the third day after subtotal thyroidectomy. We know of but one reported case of toxic goiter in which daily metabolism determinations were made during the entire course of study and treatment, namely, that of Sturgis.[2]

METHODS

The patients were prepared for the basal metabolism determinations in the usual way. All observations recorded in the data presented here were made while the patient was in the hospital. In all cases, complete rest in bed was the rule during the preoperative treatment. During convalescence, when the patients became ambulatory, there was a period of fourteen hours' rest in bed before the daily test. The evening meals were served at such time as to allow at least fourteen hours to elapse before the metabolic rate determination on the following morning. With few exceptions (four of the 126 recorded in Fig. 2) the tests were made at the bedside, usually in the patient's private room, occasionally in the open ward behind a screen. For such patients, the nurse's orders included the omission of the morning bath, changing of bedclothes, etc. The patient was not to be disturbed in any way until after the test. The tests were made at about the same time every day. Each patient was instructed to remain in a recumbent position for about half an hour before the time scheduled for the test.

In the few instances in which the test was not made at the bedside, the patient was brought to the laboratory in a wheel chair or on a stretcher, and rested for half an hour before the observations were made. The nature of the test and the significance of the term "basal" were carefully explained to each patient, and with but one exception all cooperated well. In the exceptional instance, the first few daily tests were made more or less under protest, but when the routine was established there was good cooperation. This patient was in bed for sixty-nine days before the operation, so that the data in her case that are used for this report were obtained under basal conditions so far as cooperation is concerned.

The apparatus was the portable Benedict equipped with valves (Roth) [5] except in one case, in which the motor type was used. Apparatus of the Benedict type has always proved satisfactory in this clinic. Until 1919, the so-called universal type with carbon dioxid measurements was employed; since then, the portable type with oxygen determinations only. In the fall of 1922, it having been found that

4. Eberts, E. M.: Basal Metabolism as a Guide in Surgical Treatment of Goiter with Hyperthyroidism, Canad. M. A. J. **11**:641 (Sept.) 1921.

5. Roth, Paul: Modifications of Apparatus and Improved Technic Adaptable to the Benedict Type of Respiration Apparatus, Boston M. & S. J. **186**:457 (April 6) 1922.

there was agreement between the motor driven and valve types of portable apparatus, the latter was adopted for all metabolism work of the clinic, and it has given entire satisfaction ever since. The advantages of the valve apparatus are definite: no fire risk, greater comfort to the patient because of the absence of noise and vibration, smaller temperature changes, and greater portability due to lower weight and to absence of electrical connections. This last factor was particularly important in our work, which involved carrying the apparatus from ward to ward in different parts of the hospital.

Each observation consisted of at least two seven-minute periods which checked within 5 per cent. A respiratory quotient of 0.79 was

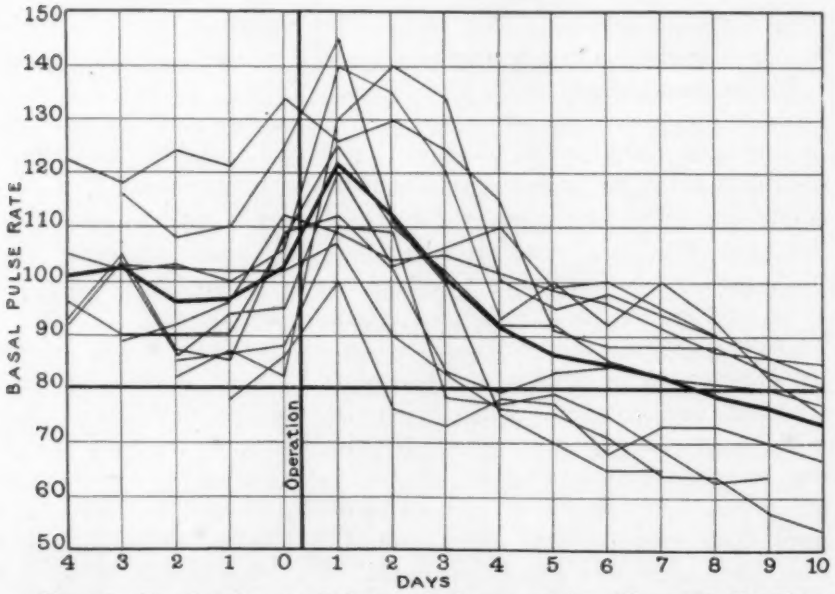

Chart 1.—Basal pulse rate before and after operation (Group 1) [In Charts 1, 2 and 3, the fine lines are the curves of individual cases; the broad line is the composite curve representing the average of all observations made.]

The relatively wide preoperative daily fluctuations in each case and also the wide variations in pulse rate between different cases of similar degree of intoxication are evident (compare Chart 2). There is a general parallelism between all curves, as is shown by the preoperative rise on the morning of operation in all but one case, and the postoperative rise in all cases. The composite curve shows that the most rapid drop is from the second to the fifth day after operation. If 80 beats a minute is arbitrarily assumed to be the average normal rate for this group, the average time required for this level to be reached is eight days.

assumed for all cases, this having been previously found by one of us (J. H. M.) to be the average postabsorptive respiratory quotient for patients with hyperthyroidism. The body surface was estimated from

height and weight according to the Du Bois formula. The patients were weighed about once every ten days; and for calculating body surface, the changes in weight were evenly distributed over the period of time during which the subject was not weighed.

The Russell Sage Institute standards of normal metabolism were employed in calculating the percentage variation from normal.[6]

The pulse was counted for a whole minute at least once during each seven-minute respiration period, and each of the points plotted on Chart 1 represents an average of at least two counts.

The temperature curves (Chart 3) were constructed from the routine 7 a. m. observations made by the ward nurse.

PRESENTATION OF DATA

The observations presented in this paper are part of the data collected in a study of the changes in the basal metabolism and pulse rates following various surgical procedures used in the treatment of toxic goiter. The fourteen cases which form the basis of this report were selected because in each instance the operation was performed in order that sufficient gland substance might be removed to produce a clinical cure and to cause metabolism and pulse to reach normal limits. In other words, the operative procedure was actually a subtotal thyroidectomy, or a secondary operation which completed a removal of gland substance, amounting to subtotal thyroidectomy. The cases have been divided into two groups according to the degree of intoxication as estimated from all available evidence. Group 1 consists of eleven cases—eight of exophthalmic goiter and three of adenomatous goiter with hyperfunction—in which the preoperative basal metabolism varied between + 36 and + 48 per cent. The three cases which form Group 2 had the typical exophthalmic goiter syndrome, and in these the preoperative basal metabolism was between + 13 and + 28 per cent. The average true basal rate in Group 1 was + 42 and in Group 2, + 22 per cent. In none of these fourteen cases were there any postoperative complications, such as pneumonia or other general infections, which could influence the metabolism and pulse rates.

The general plan was to make daily metabolism and pulse-rate observations before and after operation, and with few exceptions this was carried out. In one of the group of eleven cases, only four metabolism observations were made, on the fourth and third days before operation and on the ninth and twelfth days after. The pulse rate, however, was taken daily before breakfast, and its curve is similar to

6. Aub, J. C., and Du Bois, E. F.: Clinical Calorimetry. Nineteenth Paper: The Basal Metabolism of Old Men, Arch. Int. Med. **19**:823 (May) 1917.

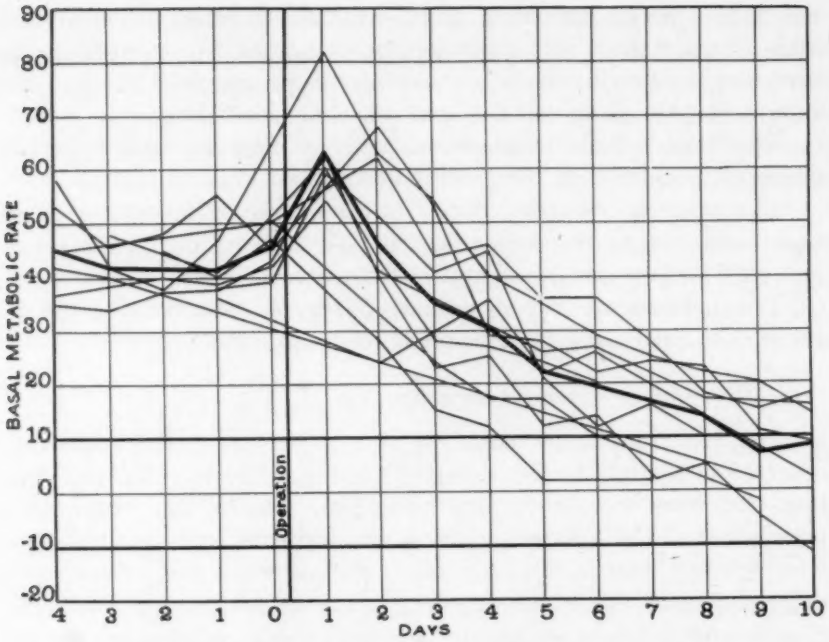

Chart 2.—Basal metabolic rate before and after operation (Group I). The preoperative daily fluctuations as well as the differences in basal metabolism between these cases of similar degree of intoxication are not so wide as those of pulse rate. The curves are smoother and are grouped together more closely than those in Chart 1. There is a general parallelism between all curves. There was a preoperative rise on the day of operation in all but one case (in two instances, no test was made on this day). The rise on the first day after operation is shown by all five cases in which the test was made. The point on the composite curve for this day is the average for these five cases. The composite curve shows that the drop in metabolic rate was most rapid from the first to the fifth day, and normal limits were reached on the ninth day.

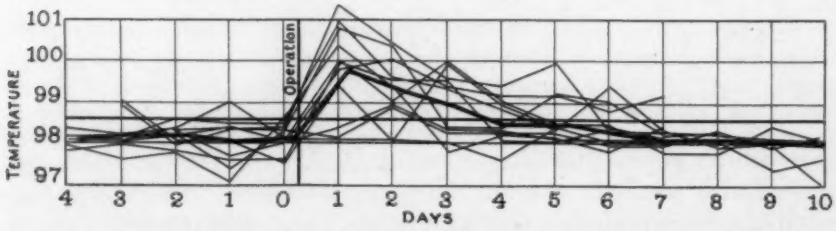

Chart 3.—Body temperature before and after operation (Group I). The preoperative temperature is usually between 98 and 98.6 F. There is no preoperative rise. The elevation on the first day after operation varies from 0 to 3.4 degrees Fahrenheit. The average drop in temperature is most rapid from the first to the fourth day; then it is more gradual, reaching the preoperative level on the seventh day.

that of the pulse rates in the ten other cases. This case is included in this group because the amount of postoperative drop in basal metabolism and pulse rates is similar to that of the remaining cases, reaching normal limits on the ninth day. On the whole, the patients cooperated admirably for all observations with the exception of those made on the first morning following operation. As a rule, on that morning they felt uncomfortable; their throats felt "sore," and some had vomited and had been generally miserable during the night. Thus, in only eight cases (five of Group 1 and all of Group 2) could we obtain satisfactory observations on the first day after operation. However, the uniform character of the results in these eight patients warrants the assumption that similar results would have been obtained in the remaining six. This is partly borne out by the fact that, in two of the six cases, the ratio on the second day after operation was still higher than the preoperative basal level. Furthermore, there was invariably an increase in pulse rate on the first day after operation, and in four cases an increased rate was maintained until the fourth day.

In all fourteen cases, the first metabolism determinations, whether they were made before or soon after the patient's admission to the hospital, were higher than the true basal level established after repeated observations. In some cases, a constant level was maintained after the second observation; whereas, in others, the drop continued for from three to five days. The difference between the first two or three determinations was always greater than that between the subsequent observations. It seems fair to assume that the earlier relatively great drop (from 5 to 35 points) is largely due to the fact that the patients are more at their ease and cooperate better after becoming adapted to hospital life and to their part in the performance of the test. The subsequent smaller and more gradual decrease in metabolism (from 5 to 15 points) is to be accounted for mainly by the rest in bed.

Twelve of the patients were in bed for a week or more before the operation, the longest period of continual rest in bed being sixty-two days in one of the cases in Group 1. In the other two cases, the patients had been studied during previous admissions to the hospital, when two ligations and a hemithyroidectomy were performed on each of them. Thus, they were already quite hospitalized and also trained in cooperating during the test, and observations made on them on the first or second day before operation may be considered truly basal.

Five of Group 1 had previously had two ligations followed by a period of rest at home varying from four to ten weeks. In two cases, the first hemithyroidectomy was performed about two months before the final operation. Thus, in Group 1, the operation consisted of a primary subtotal thyroidectomy in seven; a second hemithyroidectomy in three, and two hemithyroidectomies within five days in one case.

In all three of Group 2, the operation was a primary subtotal thyroidectomy. The operations were performed by Drs. C. A. Porter, E. P. Richardson, and G. W. W. Brewster, to whom we are indebted for permission to make our studies.

INTERPRETATION OF RESULTS

Relation Between Metabolism and Pulse.—On comparing the curves of metabolism (Chart 2) with those of the pulse (Chart 1), it is evident that the former are relatively smoother and more closely grouped together than the latter, which are more irregular and lie within wider limits. This seems to indicate clearly that the basal metabolism rate is a more accurate index of the degree of intoxication than is the pulse rate.

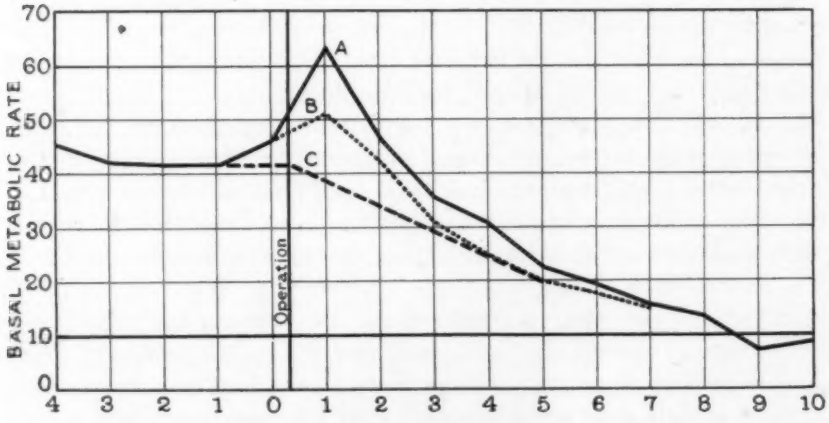

Chart 4.—True detoxication curve for Group 1. The solid black line *A* is the composite basal metabolism curve taken from Chart 2. From this is subtracted the effect that may be expected to be due to fever, shown by the dotted line *B*. The true detoxication curve may be expected to assume approximately the position shown by the interrupted line *C*. The perpendicular distance between *A* and *B* thus represents the increase in calories due to fever, that between *B* and *C* the increase due to emotion and all other causes.

Nevertheless, it is also clearly apparent that the general contour of the whole group of curves is similar in the two figures. Means and Aub [7] in 1919 drew attention to the fact that basal metabolism and pulse rates run a relatively parallel course, and this has subsequently been corroborated by other observers.[8] All fourteen cases present this

7. Means and Aub: Footnote 1, third reference.

8. Sturgis: Footnote 2. Sturgis, C. C., and Tompkins, E. H.: A Study of the Correlation of the Basal Metabolism and Pulse Rate in Patients with Hyperthyroidism, Arch. Int. Med. **26**:467 (Oct.) 1920. Read, J. M.: Correlation of Basal Metabolic Rate with Pulse Rate and Pulse Pressure, J. A. M. A. **78**:1889 (June 17) 1922.

phenomenon. It is to be expected, therefore, that the composite curves in Charts 1 and 2, as well as those in Chart 5, should be more or less parallel to each other.

It may appear that from such composite curves it should be possible to reach a conclusion as to the exact numerical relation between basal pulse and metabolism. This, however, is not possible because the normal basal pulse rate varies within much wider limits than the basal metabolism rate, and thus no reliable standard exists for purposes of comparison. Again, on comparing the coincident rise in pulse with that of metabolism, it is found that the ratios of average rise in metabolism to that of pulse are different before and after operation, and that there is a great lack of uniformity in these ratios in individual cases. Thus, no criterion exists for the exact estimation of metabolism from pulse rate. However, in view of the close parallelism between pulse and

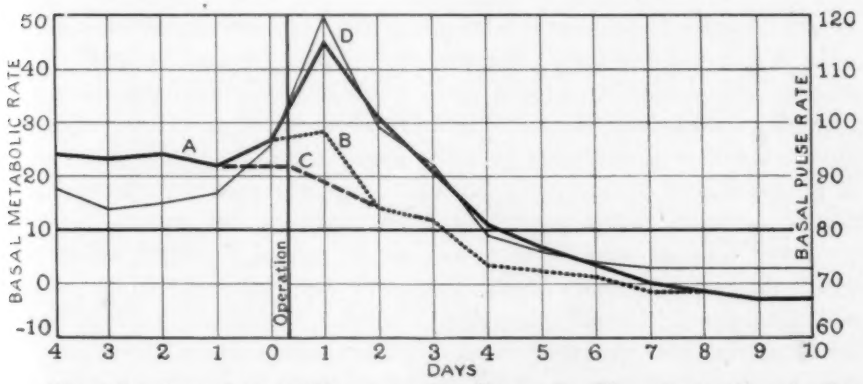

Chart 5.—True detoxication curve for Group 2. The construction is the same as in Chart 4. The additional curve *D* (firm black line) is the composite basal pulse curve for Group 2.

metabolism, a rise or fall in one suggests strongly a coincident similar change in the other. This fact is of some importance since the pulse rate may serve as a guide to indicate when metabolism determinations should be made.

Preoperative Reaction.—During the three or four days immediately preceding the operation, patients were in their most basal condition. On the morning of the operation, there occurred an increase in both rates. The average rise in metabolism was 3.7 points and in pulse 6 beats per minute. In individual cases, the increase in metabolism varied from 1 to 8 points, and in pulse from 0 to 24 beats. There was no elevation in temperature coincident with these increased rates. In one instance, there was an increase in metabolism with a fall in pulse, and in another the reverse occurred. Judging from the behavior of the patients at the time of the test on the morning

of the operation, the rise in pulse and metabolism must be due largely to psychic influences. These might easily produce an increased discharge of epinephrin, which would raise the rate of metabolism. In most instances, the patients learned about the time set for the operation during the afternoon of the day before, and some not until the morning of the operation, an hour or so before the test was made. Knowing that they were to be operated on within a few hours, they were naturally in a state of more or less perturbation in spite of the fact that they had had a small dose of morphin. The degree of this perturbation varied from milder states of excitement, described by one patient as similar to the sensation when about to start in a race, to moderately intense anxiety as to the outcome of the operation. In no case was there any degree of physical restlessness which could have vitiated the accuracy of the test. By occupying the patients' minds, the performance of the test on this morning tended to decrease their anxiety and calm them.

Postoperative Reaction.—The postoperative reaction varied somewhat in severity, but in no case was there a real "thyroid storm." All patients complained of a sore neck which made swallowing uncomfortable or even very painful. Some vomited and were rather restless during the first twenty-four to forty-eight hours after the operation. The mental state varied from that of a sense of relief that the operation was over to distress occasioned by the physical discomforts.

There was an increase in metabolism in all of the eight cases in which the test was made on the first day after operation. The pulse and metabolism followed more or less parallel lines in these cases, and the pulse was also increased in all of the remaining six. There was a rise in body temperature in all but two cases, and in these there had been some elevation during the night, and the temperature rose again on the second and third days. The amount of increase in each of these three factors varied quite widely in individual cases, as may be seen from the curves in Charts 1, 2, and 3.

Fever per se is known to be accompanied by an increase in basal metabolism. It would be interesting to know, therefore, to what extent fever alone can explain this postoperative rise that we have observed. Du Bois [9] believes in general that for 1 degree centigrade rise in temperature, there is in the neighborhood of 13 points rise in the basal metabolism rate (7.6 for 1 degree Fahrenheit). In Chart 4, the solid line represents the curve of the average of actual observed metabolism rates of Group 1. The curve B shows the average rate after the portion due to fever, calculated according to Du Bois' theory, has been subtracted.

9. Du Bois, E. F.: Metabolism in Fever and Certain Infections, Barker's Endocrinology and Metabolism, New York, D. Appleton & Co., 1922, Vol. 4, p. 95.

It is evident from these curves that of the total rise in metabolism, above the preoperative true basal level which is represented by the horizontal part of the curves A and C, about half can be explained on the basis of fever alone. An additional quarter is apparently due to preoperative excitement, which makes it not improbable that the remainder is also due to such a cause. In general, it would seem reasonable to conclude that at least the larger portion of the post-operative rise is a simple physiologic result of fever and emotion. The data at hand do not suggest any flooding of the organism with thyroid hormone due to operative manipulation.

The drop in metabolism from the peak on the first day after operation down to the preoperative level was accomplished within twenty-four hours in seven cases; within seventy-two hours in two, and within

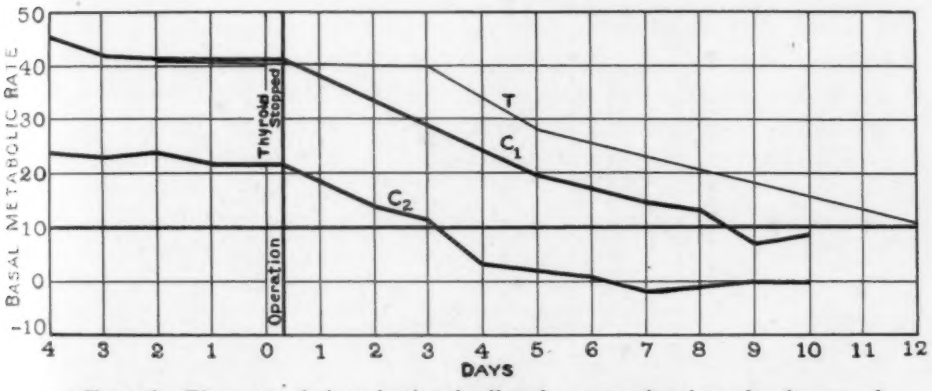

Chart 6.—The rate of detoxication is directly proportional to the degree of preoperative intoxication. There is parallelism in rates of detoxication following subtotal thyroidectomy, C_1 in Group 1, C_2 in Group 2, and T after the discontinuation of thyroid ingestion by a normal individual.

ninety-six hours in one case. When expressed in terms of days, this drop, especially in the series of seven cases, appears to be relatively rapid. It is, however, a more or less gradual decline and not a sudden fall, as may be seen from the curve in Chart 7, which expresses part of this drop in terms of hours.

Rate of Detoxication.—After the elevations in metabolism due to temperature and other factors are subtracted, there remains the curve representing the average rate of detoxication in the two separate groups of different degrees of severity. From these curves, it is evident that the rate of detoxication is a gradual one extending over a period of days. Both curves show a more rapid decline during the first four or five days, followed by a more gradual one during the remaining days.

Aub and Stern [10] report a case of thyrotoxicosis induced by ingestion of large doses of thyroid. The patient was a young woman of 24 with complete heart block. During three or four months before coming to the hospital, she had taken 2,000 grains of thyroid. Her basal metabolism rate was + 47 and + 41 per cent. on the ninth and second days, respectively, before thyroid therapy was stopped. After discontinuation of thyroid, the rate was + 40 on the third day, + 28 on the fifth day and +11 per cent, on the twelfth day. This case is of special interest to us because the basal metabolism rate before thyroid was stopped was almost exactly the same as the average preoperative rate in Group 1. The Curve T, Chart 6, represents the rate of detoxication in this case. The general parallelism between this curve and that of detoxication following subtotal thyroidectomy in Group 1 is obvious. It may be supposed, therefore, that the process of detoxication is similar in both natural and induced hyperthyroidism.

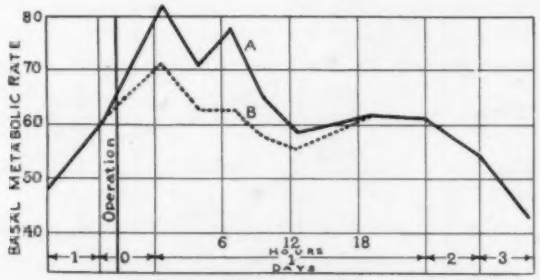

Chart 7.—Curve of basal metabolism in an individual case; *A*, observed, *B*, corrected for temperature. During the first day after operation, determinations were made at intervals of from three to four hours. Although the drop on this day is relatively great, it is nevertheless a fairly gradual one.

On Comparing Curve C_1 with C_2 (Chart 6), it is apparent that the time required for metabolism to drop to within normal limits varies directly with the degree of intoxication before operation. Thus, in Group 1, with an average preoperative rate of + 42 per cent., the basal metabolism reached a level below + 10 per cent. on the ninth day after operation; while in Group 1, with an average preoperative rate of + 22 per cent., the normal rate of + 7 per cent. was reached on the fourth day. It would seem, therefore, that the time required for detoxication is directly proportional to the severity of intoxication before removal of the gland.

10. Aub, J. C., and Stern, N. S.: The Influence of Large Doses of Thyroid Extract on Total Metabolism and Heart in a Case of Heart Block, Arch. Int. Med. **21**:130 (Jan.) 1918.

CONCLUSIONS

The early effects of operations amounting to subtotal thyroidectomy in patients with toxic goiters are:

1. In the twenty-four hours after operation, a rise in basal metabolism and pulse which can be explained largely on the basis of fever and emotion. 2. Following this initial rise, a progressive fall in metabolism and pulse which brings them within normal limits in from four to twelve days.

From the studies here reported, it is further concluded that: 3. The rate of detoxication following subtotal thyroidectomy is quite similar to that during the period of recovery from hyperthyroidism induced by thyroid feeding. 4. Since the detoxication rates of individual patients following subtotal thyroidectomy or its equivalent are in the main parallel with one another, the length of time required for detoxication will depend on the intensity of the preoperative intoxication. 5. While pulse and basal metabolism show considerable parallelism, the latter fluctuates less and is the better index of the degree of hyperthyroidism. 6. The slight rise in pulse and metabolism which usually occurs in the morning just before operation is due to an increase in emotional tension, and very likely a resulting increase in liberation of epinephrin.

TWENTY-SECOND REPORT OF PROGRESS IN ORTHOPEDIC SURGERY *

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CONGENITAL CONDITIONS

Disturbances in Epiphyses in Growth Period.—Valentin [1] refers to the affections of the hip joint, of the scaphoid bone, etc., known as the Legg, Calvé, Perthes, Koehler or Osgood-Schlatter affections, and maintains that they have nothing in common with rachitis and that trauma is only an occasional factor. He looks on it as a congenital developmental anomaly, remaining latent until the period of most active growth and exercise. The anomaly is in the epiphyseal cartilage and its vicinity, near the growth center of the epiphyses. The arrangement of the vessels at this center causes a predisposition to the affection. The familial and symmetrical occurrence and the fact that boys are almost exclusively affected, while the similar developmental anomaly in the hip joint of congenital luxation when weight-bearing begins affects mainly girls, point to a congenital disturbance in the normal process of ossification plus some endocrine influence. Demel's recent research on "hyperthymusized" animals showed a remarkable acceleration of the growth of the bones in length. In conclusion, Valentin remarks that these data have rendered the prognosis of tuberculous disease of the hip joint much graver, since there can be no doubt that the cases which have been reported as cured were merely instances of this developmental anomaly, the prognosis of which is almost always favorable. He believes these anomalies also explain growing pains.

Congenital Dislocation of the Hip, with Intracapsular Exostosis.—Storey [2] has operated in a case of congenital dislocation of the hip in

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* This Report of Progress is based on a review of 383 articles selected from 463 titles dealing with orthopedic surgery, appearing in medical literature between March 3 and July 1, 1923. Only those papers which seem to represent progress have been selected for note and comment.

1. Valentin, B.: Med. Klin. **18**:962 (July 23) 1923.

2. Storey, C. L.: Congenital Dislocation of Hip, with Intracapsular Exostosis, J. A. M. A. **80**:914 (March 31) 1923.

a girl, 13 years of age, removing an intracapsular exostosis on the under surface of the neck. He then reduced the dislocation and obtained a good result. The exostosis was 1½ inches (3.7 cm.) long and three-fourths inch (1.8 cm.) thick. The special point of interest in this case is the intracapsular exostosis. He has not been able to find a similar case in a thorough search of the literature. This case presents none of the ear marks of the type of multiple hereditary deforming exostosis described by Ollier and Ehrenfried under the name of chondrodysplasia. A traumatic displacement of osteogenic tissue from the epiphyseal line seems the most reasonable etiologic factor.

True Congenital Dislocation of Shoulder.—Greig [3] states that there are three distinct varieties of congenital dislocation of the shoulder: (1) true congenital dislocation; (2) dislocation produced by obstetric manipulation or by difficult labor, and (3) dislocation consequent on paralysis. True dislocation is often not thought of in connection with difficulty of labor. The child has no bruising or pain, and not infrequently it is some days after birth before the abnormality is realized. The author has found only twelve cases reported to date in which the evidence fails to justify the conclusion that they are cases of true primary congenital dislocation of the shoulder. He feels that a combination of muscular action and uterine pressure, accompanied or not by some spasmodic contraction of a muscle or a group of muscles, offers a possible explanation. As spasmodic affections are often bilateral and tend to be symmetrical, they would explain the bilateral affection. The nervous origin of such a disturbance would also afford an explanation of the fact that more than one member of the same family may be affected and yet the complaint not become hereditary.

Congenital Elevation of the Scapula.—Fisher [4] reports a case of congenital elevation of the scapula in which he operated. The patient was 2 years of age. He performed two operations at the same sitting: the first to remove the bony bar which ran from the upper inner angle of the scapula to the upper thoracic vertebrae; the second, to remove a V-shaped piece from the trapezius and the apex of the fifth or sixth thoracic spine. A heavy suture was passed through the inferior angle of the scapula, carried down through the muscles and brought out through the skin at the level of the eleventh or twelfth thoracic spine. The needle was reinserted at this point and brought out again through the muscles at the inferior angle of the scapula. This was tightened and thus pulled the scapula down and fixed it in place. The V-shaped rent in the trapezius was sutured as an additional measure to hold the scapula down. The result was satisfactory to the parents, who reported that the two shoulders were very nearly symmetrical.

3. Greig, D. M.: Edinburgh M. J. **30**:157 (April) 1923.
4. Fisher, A. L.: California State J. Med. **21**:203 (May) 1923.

The Anatomy of Spina Bifida.—Keiller's [5] elaborate paper presents a complete review of seven cases and discusses the whole subject. The varieties of spina bifida fall into three classes from an embryologic point of view: (1) those in which the gross defect is limited to mesoblastic structures; (2) those in which the defect is mainly mesoblastic, but in which there is a slight ectodermal defect, and (3) those in which the gross defect is ectodermal and the mesoblastic condition is a mere accompaniment. Probably in the more severe cases of Class 1 and in all the cases of Class 2, the causative factor is primarily ectodermal, but this imperfection has been obscured by the relatively normal aftergrowth. The classes may be thus subdivided: Class 1. Mesoblastic defect: (*a*) spina bifida occulta; (*b*) meningocele. Class 2. Mesoblastic defect with slight epiblastic defect: (*a*) myelomeningocele; (*b*) hydromyelomeningocele; Class 3. Gross epiblastic defect with accompanying mesoblastic defect: (*a*) myelocele, partial; (*b*) myelocele, total.

The writer has collected from the literature a total of 170 cases in which accurate anatomic data were given. The percentage of these were: 4.1 spina bifida occulta (with symptoms); 2.3 meningoceles with adherent cauda equina; 0.1 pure meningoceles; 70.6 myeloceles, and 1.7 syringomyelomeningoceles. The fact that only the meningoceles in this series presented no nerve lesions indicates that 78 per cent. of all restricted cases involve the cord or its nerve roots to some extent. From the point of view of operability and functional results, this is a matter of prime importance. Theoretically, the writer says there can be no doubt that pure meningoceles should be operated on, and in view of the possibility of ulceration or rupture of the sac, they should be treated early. Shock is less in young infants than in older children. Spontaneous cure is not to be expected in the great majority of cases, and the risks run by awaiting it are too great. In those cases in which the cord is known or suspected to be present in the sac, not only is ulceration exceedingly frequent, but also the cord below its attachment is practically useless and the attachment is dragging on the relatively normal cord above and is jeopardizing its function. The writer believes that dissecting out the cord from the sac is useless and may result in turning in of epithelium, which may cause a meningitis. All that can be hoped for is that the segments above the cord lesion may be so far as is possible preserved from further harm. To accomplish this, the end of the cord must be cut free and allowed to slip up into the canal. Except in rare cases, all that may be hoped for by operation is that the function of the segments of the cord above the lesion will not be subjected to further impairment by traction of fluid or the presence of inflammation. No improvement in function can be promised or even expected.

5. Keiller, Violet H.: Brain **45**:31 (June) 1922.

Incontinence Due to Spina Bifida.—Delbet and Léri [6] report a case of enuresis with occult spina bifida. They removed a transverse fibrocartilaginous band which compressed the cauda equina, and the patient recovered. The sacral region should be examined by roentgen rays in every case of persistent incontinence of urine. If a spina bifida is found, an operative exploration reaching as deep as the dura mater should be performed.

Hackenbroch [7] also describes a case of spina bifida with claw cavus deformity of both feet, extreme cyanosis and coldness of the lower legs, and enuresis nocturna. The last named symptoms disappeared immediately after the operation, which consisted of laminectomy and excision of a tumor of normal muscular tissue, fibrous masses and adhesions of the spinal cord. The deformity of the feet was much improved by tenotomy of the Achilles tendon, a wedge-shaped excision of the tarsus and excision of the plantar fascia.

Paralysis from Occult Spina Bifida.—Hoelen [8] reports a case of bilateral paralysis of the peronei resulting from spina bifida occulta in a girl at puberty. The condition was relieved by removal of a mass of fat and connective tissue which protruded into the spinal canal through the deficiency of the first sacral arc. There were no trophic disturbances in this case, but there was slight vasomotor derangement.

Marie and Léri [9] record the case of a woman of 46, who, without any previous disturbance during her entire life, gradually developed at this age a spastic paralysis of the four extremities. Neurologically, the lesion was placed at the level of the eighth cervical cord segment. Roentgen examination revealed a marked hiatus in the posterior spinal arch of the seventh cervical vertebra, with a completely bifid spine. Extension of the hiatus into the body of the vertebra could not be demonstrated. There were none of the usual external evidences of spina bifida. They felt that the extremely late development of the symptoms was due to the presence of a fatty or fibrous tumor, which is frequently associated with such lesions, but no operation was performed, so they were unable to prove their contention.

[Ed. Note.—It is evident from a review of this series of articles that more attention is being focused on this congenital lesion and that since the discovery of the roentgen ray the existence of a spina bifida occulta is becoming associated with various symptoms and signs, enuresis, lower limb deformities, club feet, claw feet, and even late

6. Delbet, P., and Léri, A.: Bull. Acad. de méd. **89**:49 (Jan. 9) 1923.
7. Hackenbroch, M.: München. med. Wchnschr. **69**:1191 (Aug. 11) 1922.
8. Hoelen, E.: Nederlandsch Tijdschr. v. Geneesk. **1**:252 (Jan. 20) 1923.
9. Marie, Pierre, and Léri, Andre: Bull. et mém. Soc. méd. d. hôp. de Paris **46**:1138 (July 21) 1922.

paralyses. The relief obtained in many cases by operative removal of pressure from constricting bands and slowly developing tumor masses emphasizes the importance of suspecting this congenital deformity in otherwise unexplained conditions and of determining its possible causal relation before being satisfied with merely local treatment of the remote lesion.]

Congenital Curvature of the Tibia.—La Ferla [10] uses the term "congenital curvature of the tibia" to signify a rare deformity which is usually localized between the middle and the lower thirds of the tibia. This curvature may exist singly, that is, in the tibia, or in both lower leg bones. Frequently, the curvature is complicated by a pseudarthrosis which may involve either one or both of the bones. Sometimes, in the new bone, one observes a fracture of the tibia which results in a pseudarthrosis responding very reluctantly to treatment. According to Gasne, the clinical deformity varies in different cases according to its type and its method of evolution. Nevertheless, all clinical forms may be included in four classes: Class 1. Curvature of the bones of the leg which form an angle projecting forward beneath the skin as in a fracture, but with no abnormal mobility. The condition is present at birth. Class 2. A lesion presenting itself at the beginning, as in Class 1, but following an injury, frequently slight; or sometimes following some operative manipulation a fracture is produced, and this pseudarthrosis shows almost no tendency to cure. Class 3. A pseudarthrosis present from birth. Class 4. A lesion which does not present itself at birth as far as external evidence goes; but sometime afterward in consequence of an injury a fracture is produced and subsequently a pseudarthrosis which is very resistant to ordinary treatment develops. Codivilla, basing his conceptions on morphologic and roentgenologic grounds, has proposed three groups in which it is possible to classify the various cases of congenital pseudarthrosis of the tibia: Class 1. Deformities consisting of an angular deviation of the tibia, at the apex of which a transparent section shows that the normal osseous tissue is lacking in that part. The fibula is curved, but in the size and density of the roentgenographic shadow is entirely normal. The same may be said of the two segments of the tibia. Class 2. Cases showing a true tibial pseudarthrosis. The inferior bony segment is formed at its extremity into what appears as an articular head, which is received into a glenoid cavity created in the superior segment. Class 3. Those cases which have marked exaggeration of the features of the second class. Strictly speaking, one can no longer consider the condition one of pseudarthrosis, but of a true and extensive loss of the substance of the tibia and fibula.

10. La Ferla, Luigi: Chir. d. org. di movimento **6**:243 (April) 1922.

Codivilla believed that the reason for the deformity is always a deficiency in the activity of the tissues which take part in the formation of bone, especially on the part of the periosteum, and excludes the cause which is frequently considered the agent in many deformities, that is, amniotic adhesions. He, in his cases, never found definite evidence of adhesions, and furthermore the seat of the lesions is so constantly at the junction of the middle and lower thirds of the tibia or a very little below this point that one suspects more readily a developmental abnormality or some other factor which inhibits the normal development of circulation of blood in the tibial diaphysis. He thought that the lack of circulation, due to the nutrient artery of the tibia, could explain the production of a loss of continuity which exists in the same region.

The cure of congenital deformity and pseudarthrosis is uncertain, since the methods ordinarily employed, which give good results in cases of acquired pseudarthrosis, are without effect in congenital pseudarthrosis. The treatment varies from case to case, and no rules can be established. In some of the least serious cases, it has been sufficient to resect the area of pseudarthrosis, or the angle of curvature, and hold the parts immobilized in contact for a long time. In other cases, success has been obtained by bone grafts, which furnish the pseudarthrotic area more active osteoblastic tissues. In the cases of congenital pseudarthrosis with bone atrophy and a wide loss of the tibia, it is necessary to provide for the continuity of the two portions by some osteoblastic portion. Thus Codivilla in one of his cases of congenital pseudarthrosis succeeded in accomplishing his purpose by means of a massive bone transplant which he took from the fibula of the other leg and of which he maintained the nutrition by a temporary muscle flap. The author reports a case of a child of 5 years at the time of whose birth a little swelling was noticed on the lower third of the right leg. The swelling increased as the child began to stand. The deformity, however, for more than a year had not increased. The examination showed a marked curvature of the right leg at an angle of 135 degrees. The roentgenogram showed that the deformity was formed by an angulation of the axis of the tibia, and also showed a deviation in the form of the bone in the upper segment and in the lower segment. The section of the upper segment nearest the angulation was thicker than the remainder and the bone much denser. The distal segment was uniformly smaller. Near the angle of the curvature, there was a paler zone, indicating a diminution of the calcareous material. The same roentgenogram showed an angulation of the fibula at the junction of the upper four-fifths and the lower one-fifth. At the operation, the tibia was exposed at the site of deformity. Firm union was found. After separation with a chisel, a cuneiform piece was

removed. Manual osteoclasis of the fibula was then done, and it was easily possible to correct the deformity. The wound was closed and the limb immobilized. Some infection followed, and a sequestrum was eliminated about three months after operation. The wound then closed at once. About six months after operation, it was possible to leave off all protective apparatus. There was shortening of the leg of 4 cm. The roentgenogram showed very fair position of the fragments. This case belongs in the first group according to the classification of Gasne, and in the first group of Codivilla according to the roentgenographic examination.

Treatment of Club Foot.—Geist [11] has encountered 127 cases of club foot in five consecutive years of practice. Of these, ninety-one cases were congenital and thirty-two acquired. He believes that treatment should be instituted in the first or second week after birth and should consist of gradual correction by means of successive plasters. Overcorrection should be accomplished before tenotomies and fasciotomies, which should not be performed before the seventh or eighth months. If this rule is not followed, relapses are almost sure to occur. In old neglected cases, he prefers removal of a wedge of bone on the outer side of the foot to astragalectomy. In about 10 per cent. of the cases, there is an inward rotation of the tibia, which should be corrected by osteotomy, an operation proposed by Willy Meyer twenty years ago. The majority of the acquired cases follow poliomyelitis, and in these cases tendon transplantation after the Meyer-Biesalski technic is often most satisfactory.

Schultze [12] most emphatically calls attention to the prime importance of correcting the twist of the os calcis in cases of congenital club feet. Unless this is accomplished early (within the first six months), he considers a satisfactory result most unlikely.

[Ed. Note.—In our experience, tenotomies and fasciotomies are practically never necessary, even in extreme cases, if the treatment by successive plasters is begun in the first few weeks after birth. Moreover, these operations frequently are inimical to future perfect function by causing weakness and diminished flexibility. We agree with Schultze that early correction of the twist in the os calcis is essential. In the old neglected cases, we have been impressed and delighted at the ease with which overcorrection may be made possible by the architectural operation of Hoke on the neck of the astragalus, the subastragaloid, calcaneocuboid and astragaloscaphoid joints. Thus far, there seems to be no tendency to relapse, and the nondeforming stabilization has been most satisfactory to the surgeon and the patient.]

11. Geist, E. S.: Journal-Lancet **43**:169 (April 1) 1923.
12. Schultze: Ztschr. f. orthop. Chir. **43**:406, 1923.

Supernumerary Digit on the Os Calcis.—Crainz [13] reports an interesting case of a supernumerary digit attached to the outer side of the os calcis. From a very careful study of the formation and development of the extra digit, the author believes it furnishes a confirmation of Gegenbauer's theory of the development of the human hand and foot. In this theory, the pisiform is considered not a sesamoid but the remains of an arrested sixth digit such as exists, more or less developed, in several of the lower vertebrates.

Hereditary Symmetrical Osteitis of the Lower Limbs.—Camurati [14] describes a case of hereditary symmetrical osteitis involving the lower portions of the femora and the upper portions of the tibiae and fibulae, occurring in four generations, once in the first generation, three times in the second generation, four times in the third generation and twice in the fourth generation. Roentgenographic studies were made of two cases, one in the fourth generation in a boy of 7 years, and the second in his father, a man of 55 years. In the child, the roentgenogram showed an increase in the size of the lower ends of the femora and in the upper ends of the tibiae and fibulae. The epiphyses were not involved. The increase in size was due to overproduction and increased density of the compact cortex. The roentgenograms of the father showed much the same appearance except that the condition was much more marked and the epiphyses were involved. The symptoms in both cases were vague, but rather severe pains occurred at various times without known exciting causes, and were endured from infancy to early adult life. This history was characteristic of all the cases reported. The diagnosis seems to be restricted to some hereditary bone affection. Hereditary syphilis and Paget's disease were the two conditions to be considered, and of the two syphilis was the more probable, although the Wassermann reaction was negative in both father and child.

TUBERCULOSIS

Types of Tubercle Bacilli.—Fraser and Mitchell, 1912-1914, first called attention to the rôle of the bovine type of tubercle bacillus in surgical tuberculosis. Griffith reported 395 cases showing the bovine type in a large number of cases, from 25 to 30 per cent., especially in childhood. In adult life, practically all cases are due to the human type. Girdlestone [15] reports a scientific bacteriologic study of these two types and the atypical strains. He finds the same percentage of bovine cases in bone and joint cases of childhood and also shows in a series of 108 cases of cervical gland tuberculosis that the bovine type was the cause

13. Crainz, Silvio: Chir. d. org. di movimento, April, 1923.
14. Camurati, M.: Chir. d. org. di movimento, November, 1922.
15. Girdlestone, S. R.: J. Bone & Joint Surg. **17**:204 (April) 1923.

in from 60 to 70 per cent. There was marked reduction of virulence in only forty-six of 1,068 cases, and of these forty-four were skin tuberculosis. The attenuation of tubercle bacilli is apparently then the rule in skin lesions. Is it not possible that there may be some very real relation between this reaction between the skin and the bacilli in lupus and scrofuloderma and the beneficial action of the sun and the wind in treatment? And may not this function be developed and used to a much greater degree? The bacilli fall into three groups: human; bovine; atypical (comparatively small but quite distinct). The proportion of cases for which bovine bacillus is responsible varies to some extent with regard to the site of the lesions; e. g., they play a larger part in gland than in bone and joint tuberculosis, but the variation due to age differences is much more marked. Their responsibility is great during the first five years of life and is rapidly reduced after the age of 16. The various strains of bacilli in each group give consistently the reactions characteristic of that group. Strains of bacilli giving intermediate reactions are almost unknown. In no instance have bovine or atypical strains, when investigated at intervals in the same case, shown change of cultural or virulence reactions toward the human. Further investigation at longer intervals is needed. There is no experimental evidence that the atypical group is composed of bacilli whose characteristics are changing from bovine to human type as a result of human environment. Tubercle bacilli of lowered virulence are found exceedingly rarely except in connection with tuberculous lesions involving the skin; on the other hand, in cutaneous lesions bacilli of lowered virulence are common, and this is most marked in lupus, a condition in which the more superficial layers of the skin are involved over long periods. This is a further reason for our belief that the skin is an organ particularly valuable in the contest between man and the tubercle bacillus. Scarification and inunction, or intradermal inoculation of tuberculin, may prove of exceptional benefit in the treatment of all forms of tuberculosis.

The Diagnostic Value of Tuberculin.—In Lange's clinic, Schultz [16] has studied the value of the various methods of tuberculin application for diagnostic purposes. In thirty-seven cases of doubtful etiology, he has used in succession Pirquet's method, the intracutaneous method and the subcutaneous injection in gradually increasing doses. He comes to the conclusion that the value of tuberculin for diagnosis is limited. A negative intracutaneous reaction is an indication against tuberculous infection and against the tuberculous character of the local focus. The focal reaction is unreliable and its specific value may be doubtful.

16. Schultz, T. I.: Ztschr. f. orthop. Chir. **43**:378, 1923.

The Phosphate Content of the Blood.—Tisdall and Harris [17] have studied the phosphate content in eighteen cases of surgical tuberculosis that showed improvement under heliotherapy. From the results, it is apparent that the deposition of new bone which occurs during the cure of bone tuberculosis is not accomplished by an increase in the inorganic phosphate content of the blood serum such as occurs during the cure of rickets. In many cases, the concentration of phosphorus was found to be actually below that present in normal serum. No increase was found to occur in the inorganic phosphate content of the serum in three cases of soft tissue tuberculosis, two of which were improved by treatment.

Trauma as an Etiologic Factor.—The *Presse Médicale* gives a summary written under the pseudonym of Sénèque,[18] of an investigation which has recently been conducted in Switzerland of the old question of relation between traumatism and tuberculosis of the bones and joints. A review of the experimental field shows that much work has been done by different investigators. Inoculation experiments have been performed by different persons with tuberculous material injected intravenously, subcutaneously and by mouth, certain of the bones having first been traumatized. These experiments have yielded generally uniform results. A generalized tuberculosis has rapidly followed the inoculation, and although, in certain cases, tuberculous lesions have developed at the traumatized site, whether bone or joint, so also have they developed in many other nontraumatized bones and joints. It seems to have been demonstrated that the process of repair at the site of a fracture hinders the development of tuberculous lesions. In contradistinction to these results, Petrow alone has obtained positive results. His experiments followed the foregoing lines, the animal used being the rabbit, and the trauma being produced by a sprain of the knee. He obtained eleven positive results following eighteen mild sprains (two other nontraumatized knees in these series also developed tuberculosis), and eighteen articulations, which were only slightly contused, remained unaffected. Pathologic study has revealed little evidence of a postive nature. Hart has reported two cases, one of tuberculosis of the suprarenal following a gunshot wound in the lumber region; the second, tuberculous peritonitis following a gunshot wound of that cavity, but necropsy showed tuberculosis of the tracheobronchial lymph nodes, and the trauma can only be considered to have acted as a mobilizer of the infection. On the other hand, necropsies have demonstrated with considerable frequency the presence of latent tuberculous foci in the bones. From the clinical side, the study is taken up follow-

17. Tisdall, F. F., and Harris, R. I.: Canad. M. A. J. **13**:177 (March) 1923.
18. Sénèque: Presse méd. **31**:258 (March 17) 1923.

ing the classification of Jeanbrau: 1. Inoculated tuberculosis. Numerous cases have been recorded of inoculation of tuberculosis from direct implantation through abrasions in the skin. The subjects include medical students, nurses, washwomen, veterinarians and butchers. Only exceptionally in these cases have tuberculous lesions developed in the bones and joints and the process has, for the greater part, remained localized in the soft parts at the point of entrance. In the cases in which the process has extended, it is still possible to ask if diminished resistance in predisposed subjects has not played a part. 2. The reawakening of old dormant tuberculous lesions. In the cases which have been recorded that fall into this class, the trauma has usually been altogether insignificant, such as a sprain or a contusion. In these cases, the rôle of trauma seems to have been rejected, and often it is the presence of an indolent tuberculosis which is responsible for the injury by causing atrophy and relaxation of the ligaments and weakening of the muscles sufficiently to impair the protective mechanism and expose it to trauma. In these cases, active tuberculosis is the primary condition, and the trauma is incidental. 3. Aggravation of a previously present dormant tuberculous process. In this group of cases, the rôle of trauma seems undeniable. All surgeons agree that immobilization is the best method of treatment of tuberculosis and, conversely, that any interruption of this immobilization by accidental trauma, such as fracture of an old ankylosed knee of tuberculous origin, is most likely to cause an aggravation of the lesions, if it is active, or the reawakening of a lesion which seems extinguished. 4. Tuberculous lesions entirely confined to the bones or joints. Here clinical studies show a wide difference of opinion as to the importance of trauma, as is shown by the estimate of different surgeons, the estimate of the number of cases in which trauma has figured as a cause varying from 3 to 55 per cent. The rarity of a history of severe trauma in these cases is also impressive. Broca studied 500 children who had suffered minor injuries such as sprains and contusions, and in none did a localized tuberculous process develop in the traumatized part, in spite of the fact that, in some, active tuberculous lesions in other organs were already present. There is no case on record of the transformation of a traumatic arthritis into a tuberculous arthritis.

Study of medicolegal cases shows that many of the cases which have served as precedents, on which later court decisions have depended, have been based on errors. These errors consist (1) in assuming that a preexistent tuberculous lesion was a sprain when the case was seen immediately following some minor injury, and only later recognizing its true character, and thus assuming that it was secondary to trauma; (2) in making the opposite type of error and assuming lesions to be tuberculous which in reality were not. Descöeudres looked up the dossiers

in sixty-one cases of supposed tuberculosis, and found seven cases of mistaken diagnosis, and yet legal decisions had been rendered awarding damages in view of a traumatic tuberculosis. Careful clinical examinations and roentgenographic examinations must be used to avoid these errors. As for treatment, surgical treatment is favored on account of the saving of time and the good functional results which are obtained.

Iodin Treatment in Tuberculosis.—Grekow [19] recommends intramuscular injection of iodin, 1.0 c.c. of a 10.0 c.c. emulsion composed of iodoform with 1.0 c.c. of tincture of iodin, in cases of surgical tuberculosis. The iodin produces a marked lymphocytosis which acts by dissolving the capsule of the tubercle bacilli and thus killing them. Grekow has seen cures of 50 per cent., whereas in only 10 or 15 per cent. was there no benefit whatsoever, in those cases no lymphocytosis being noticeable. The injection should be repeated once a week for about ten weeks. Petraschewskaja [19] prefers to make these injections into the column ischiorectale, as they are less painful at that place. There is usually a general reaction with rise of temperature, which lessens with repeated injections. He agrees with Grekow as to the marked lymphocytosis caused by the injection.

Bock [19] discusses Mauchin's method of treatment of surgical tuberculosis with roentgen ray. Polymorphonuclear leukocytes are thus destroyed, setting free antibodies. The treatment is given once a week, seven treatments being all that are needed. The number of leukocytes and eosinophil rises. The general condition was improved in all eleven cases which have been under this treatment.

Tuberculosis of the Shoulder.—Baron [20] describes a new method of operation in certain cases of tuberculosis of the shoulder joint, the purpose being to bring about an arthrodesis in a useful position. From a posterior hooklike incision, the upper epiphysis is dissected from the diaphysis within the healthy tissue, and the diaphysis placed in an abducted position and fixed into a hole in the shape of a trapezoid chiseled out of the lateral margin of the scapula directly below the articular process. The epiphysis remains in its place. In one cited case, complete consolidation took place within two months, and two months later the arm showed strong and useful function, allowing active elevation beyond the horizontal line. The method is indicated in patients beyond the fourteenth year of age, especially in cases of caries sicca, when conservative treatment has not yet shown a satisfactory functional result and resection is not suitable on account of the extensive pathologic process and the considerable atrophy of the muscles. It is also applicable to cases

19. Grekow, Petraschewskaja and Bock: Zentralbl. f. Chir., Jan. 13, 1923, No. 2, p. 73.

20. Baron, A.: Zentralbl. f. Chir. **50**:477 (March 24) 1923.

presenting only a slight and painful motion of the adducted joint and in the absence of sinuses.

Riely [21] makes a strong plea for the recognition of Pott's disease in the adult. He quotes Richard Cabot's assertion that out of seventeen necropsies in which Pott's disease was found, the diagnosis was made only four times. He points out the difference between Pott's disease in adults and in children. He ends his article by calling attention to the fact that these cases are often mistaken for other conditions on account of the referred pains and functional organic disturbances, especially in the adult, and more particularly in the female. On account of the long time necessary for the destruction of the bone and the variable symptoms and different causes that produce pressure on the cord, there is constant necessity of roentgenographing the entire spine and sacroiliac joints. A thorough history is a most dependable means of reaching conclusions. A rigid physical examination and a careful study and proper interpretation of the roentgenographic findings is essential.

Nové-Josserand,[22] in a general article, part of a symposium, discusses the various methods and indications for orthopedic apparatus in Pott's disease. Above all, as the only means of securing complete immobilization, he advises recumbency for a prolonged period. Aside from cases in which there is a marked kyphos which necessitates correction, he has not found the plaster bed necessary, but uses a mattress on a board. For cervical Pott's disease, he uses traction, but he considers that some of these cases, especially those showing little involvement of the bodies of the vertebrae, may be treated by the ambulatory method, with a Minerva jacket. For the rest, he considers orthopedic apparatus a snare and a delusion and advises its use only in the convalescent stage.

[ED. NOTE.—We find ourselves in agreement with these views as to the inefficiency of ambulatory apparatus in the treatment of Pott's disease in the acute stage. The protection which they afford is too incomplete to accomplish its purpose.]

Boos [23] gives a critical and elaborate review of his experience with old cases of Pott's disease in which operation was performed years ago after Albee's method, and comes to the conclusion that this method is not an absolute safeguard against the progress of the disease or against the increase of the deformity. He protests that, in many favorable reports, the results cited cannot be considered as end-results, for the time elapsed since the operation has been too short. Only elaborate

21. Riely, C.: W. Virginia M. J. **17**:321 (Feb.) 1923.
22. Nové-Josserand, G.: Bull. méd., Feb. 24, 1923, p. 236.
23. Boos: Ztschr. f. orthop. Chir. **43**, 1923.

case histories and a series of roentgenograms give a true picture of the end result. Boos calls further attention to the important fact that many times the local tuberculous disease has not come to a standstill, though the local spinal process seems to indicate a perfect cure. He believes that the best time for the osteoplastic operation is after a certain amount of fixation has been obtained. It must be borne in mind that the ideal treatment is complete rest for a long period, whereas early osteoplastic operation with early weightbearing but a few months afterward involves grave dangers. A particular indication for operative treatment is given in cases of long standing in which the tuberculous focus has healed but the spine has not regained sufficient stability. When the osteoplastic operation is performed at an early stage of the disease, general and local after-treatment should be just as thorough as if no operation had been performed at all. Progressive caries, and especially the formation of cold abscesses, is not necessarily halted by the operation. Of great importance is Boos' repeated observation that the shape of the implanted graft may change with the progress of the deformity of the spine. That means that the graft alone cannot warrant the supportive function, but that it adapts itself according to mechanical and biologic laws. In regard to the indications, Boos' observation of gradual absorption of the graft in marantic children with old sinuses is of value. Such cases should be excluded from operation. Boos, who cites Hössly's experiments on dogs, believes that conditions in the experiment cannot be compared with those of the tuberculous patient. The graft is transformed from a compact cortical into a spongy bone, and disappears at times in the roentgen-ray pictures and is not dependent on diminished function. Extreme strains in early weight bearing lead to localized atrophy, showing so-called zones of transformation on the plate. Of eleven patients operated on at an early stage at the author's clinic by a competent surgeon and afterward treated as well as possible by heliotherapy and other general and local treatment, two died, seven are not yet cured, years after the operation, and only two are considered cured. Boos does not condemn the osteoplastic operation, but strives to define its field of usefulness.

Koenig [24] rejects the recent recommendation of Lange's method of ankylosing the spinal column in Pott's disease by celluloid rods, and prefers Albee's method of autotransplantation. He also rejects the modification of Halstead and Polya, who place the tibial graft beneath the base of the temporarily resected spinous processes, as well as the method of Henle who applies two tibial grafts alongside the dissected spinous processes on the laminae of the vertebrae. Both methods are in his opinion decidedly inferior to Albee's, which is now used in all suitable cases in the surgical clinic in Koenigsberg.

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24. Koenig, Ernst: Zentralbl. f. Chir., Jan. 27, 1923, p. 119.

[Ed. Note.—It is worthy of comment in considering these articles that there seems to be a definite conclusion that operation alone will not cure Pott's disease. There seems to be also a desire for a more fixative operation. We believe that fusion operations in adults have given better results by far, especially when employed to prevent further deformity. We also believe that fusions of the spine of whatever type must be followed by prolonged after-care, utilizing all the known aids for procuring a recovery from the general tuberculous condition.]

Tuberculosis of the Sacro-Iliac Joint.—Nuttall [25] does not approve of the old operations of trephining and scraping in this condition, asserting that they are not based on a sound conception of the anatomy and pathology of the joint, and the results are poor. Much better results are to be expected from more radical treatment. Nuttall commends Picque's method, which is based on the following principles: (1) an approach to the joint by cutting away the posterior overlapping portion of the ilium; (2) the resection of more or less of the sacrum, as may be necessary, for the complete evacuation of any intrapelvic abscess, and (3) the methodical following up of the disease by means of the gouge or curet, so that a smooth granulating surface may be formed without pockets or sinuses.

[Ed. Note.—The cases of sacro-iliac tuberculosis in which arthrodesis has been performed through the Smith-Petersen incision have given such satisfactory results that we would unhesitatingly recommend this radical treatment in many early cases.]

Tuberculosis of the Knee.—Delore and Dunet [26] report a case of parasynovial tuberculosis of the knee occurring in a girl of 15. It was situated in the suprapatellar region, involving the tendon of the quadriceps and particularly the fleshy portion of the vastus externus. It was entirely extra-articular, and was treated by excision. A report obtained two years later showed that the patient had remained well, and there has been no recurrence of the trouble. The authors find that parasynovial tuberculosis has been reported frequently, its favorite site being in the tendon sheaths of the wrist and ankle, whence it may extend into the neighboring joint. The condition is unusual in the region of the knee and elbow.

RICKETS AND OSTEITIS FIBROSA

A Summary of Our Knowledge of Rickets.—A recent editorial article [27] discusses the problem of the cause of rickets, which it main-

25. Nuttall, H. C. W.: Lancet **1**:839 (April 28) 1923.

26. Delore, X., and Dunet, C.: Presse méd., May 5, 1923, p. 408.

27. A Summary of Our Knowledge of Rickets, editorial, J. A. M. A. **80**:1853 (June 23) 1923.

tains is approaching solution, but it is admitted that the interplay of the various factors influencing the satisfactory deposition of calcium phosphate in the growing skeleton is still obscure. Certain investigators were of the opinion that rickets is an infectious disease, whereas others were definitely committed to the view that the disease bears a certain relationship to diet. Professor Pirquet states that he himself believed that rickets was of an infectious origin, but following three years of conscientious work he now has been convinced that the disease is definitely associated with a diet poor in fat-soluble vitamins and with the absence of sunlight. Extensive clinical investigation suggests the final establishment of views regarding the cause and therapy of rickets which mark an epoch in the control of this disease. It has been shown that the following factors play a part in the etiology of rickets: (1) an organic factor in diet concerned with the calcification of bone; (2) light, and (3) an adequate amount and correct balance in the diet of the salts of calcium and phosphorus. Mellanby, McCollum, Hess and Unger have shown the importance of the organic factor; Palm in 1890 suggested the importance of sunlight. Huldschinsky in 1919 showed the curative effect of radiation from the mercury vapor lamp. It now only remains to show the extent to which each of these primary factors operates.

Korenchevsky [28] has been carrying on a series of investigations of the effects of a diet deficient in fat soluble factor on the composition and structure of the skeleton of rats. These have been previously reported. He now reports the results of work carried on with feeding of excess calcium. On the basis of these experiments, he draws the following conclusions: 1. Butter bought in the winter may contain a considerable amount of the antirachitic principle. 2. While the amount of calcium in a normal diet containing 3 per cent. butter and 2 per cent. cod liver oil was increased two or three times, the calcification of the skeleton was either not increased or only slightly. 3. The ingestion of even very large quantities of calcium did not overcome the rachitic calcium impoverishment of the skeleton of rats on a diet deficient in the fat-soluble factor. 4. When the exhaustion of the fat-soluble factor in the body of rats is not complete, an excess of calcium in diets deficient in the fat-soluble factor may in some cases slightly increase the amount of calcium in the skeleton, though never sufficiently to make the calcification normal. 5. On the basis of the data of the chemical and histologic examination, the skeletal affections in rats which have been fed on a diet deficient in the fat-soluble factor must be classed in the group of rachitic affections which develop even with an excess of calcium in the diet.

28. Korenchevsky, V.: Brit. M. J. **1**:802 (May 12) 1923.

PARALYTIC DEFORMITIES

Stabilization of the Foot. The Treatment of Flail Ankle. Pan-Astragaloid Arthrodesis.—Steindler [29] describes the various types of arthrodesis (Whitman, Davis, Hoke, Goldthwait and Jones) and bases his operation on the complete supra-astragaloid and infra-astragaloid arthrodesis of Goldthwait. The method used by the writer is essentially a modification of the technic devised by Goldthwait, but with the extension of the fusion to all joints of the ankle except the articulation between the cuboid and calcaneum. The cases which have been largely selected for the use of this method were those of drop foot and dangle foot. He has found that the most suitable position of the foot following operation is that of perfect lateral alinement, with about 20 degrees of drop, corresponding to from three-fourths to 1 inch (1.8 to 2.5 cm.) of plantar flexion. A greater drop of the foot is not so well tolerated, even if it might seem advisable to equalize the shortening of the limb. A plaster-of-Paris cast applied in the position described, extending over the slightly flexed knee, remains in place from three to five months, after which it is replaced by an ordinary strong boot. A flail foot, not deformed, associated with a good knee or at least good or fair knee flexors is best suited for this method. The ankylosis obtained by this method is thorough and solid, and roentgenograms show complete fusion of the joints in a large majority of cases. The gait is firm, and with few exceptions, painless. The condition of the knee is of great influence on the stability of the ankle. The fusion in a slight equinus position has a tendency to stabilize the knee. Any residual contraction of the knee must be overcome beforehand. Any disalinement between the knee and ankle, such as inward rotation of the patella, should be corrected afterward. This latter complication calls for an osteotomy of the tibia with outward rotation of the leg above, and this measure has been applied in several cases with material improvement of the gait. Of thirty-six cases in which operation was performed by this method, thirty-five were infantile paralysis. The youngest patient was 17, and the oldest 40 years old. Paralysis of the ankle alone existed in nineteen cases, and paralysis of the ankle combined with that of the knee and hip, in sixteen cases. The duration of the paralysis ranged from one and one half to thirty-nine years. The types of residual deformity were distributed as follows: paralytic dropfoot, nineteen cases; paralytic, equinovalgus, six; paralytic calcaneovalgus, three; paralytic equinocavus, two; paralytic equinovarus, five.

Arm Type, the Surgical Reconstruction of the Paralytic Upper Extremity.—Steindler [30] sees four major problems to be met in para-

29. Steindler, Arthur: J. Bone & Joint Surg. **5**:284 (April) 1923.
30. Steindler, Arthur: Illinois M. J. **43**:197 (March) 1923.

lytic conditions of the shoulders: 1. The power of abducting the arm. 2. The flexion of the elbow. 3. The hyperextension of the wrist. 4. The closing and opening of the fingers, with abduction and adduction of the thumb. In about 9 per cent. of the cases of poliomyelitis the upper extremity is affected, and in 80 per cent. of these cases, the deltoid is involved. Loss of flexion of the elbow occurs in 50 per cent.; the loss of the extension of the wrist and flat hand are less common. These four conditions as residual paralysis can be fairly well met by operation. Arthrodesis of the shoulder joint gives a very good result. Flexion of the elbow may be supplied by transplanting the origin of the flexor muscles of the forearm to a point high up (2 inches, or 5 cm.) on the humerus. Arthrodesis of the wrist is most satisfactory and leaves any tendon that may have muscle power to be transplanted to assist another. Loss of power of opposition in the thumb can often be overcome by transplanting half the flexor longus pollicis of the thumb to the basal phalanx of the thumb, carrying it around the metacarpal. More complicated special operations are often needed, but in the author's hands the results from these four methods have been good.

Atrophy. Retardation of Growth Following Poliomyelitis.—Nathan [31] states his opinion that, although the retardation of the growth bears no relation to the number of muscles paralyzed or the vasomotor disturbances, it seemed to him there exists a fairly constant relation between the shortening and the paralysis of certain muscles. He found that in adults or older children in whom the morbid condition had existed for many years a short leg always meant gastrocnemius with or without tibialis posticus, palsy. He made a study of seventy cases of poliomyelitis of the 1916 group. The cases in this series definitely show that gastrocnemius and tibialis posticus palsy almost invariably lead to retardation of growth in the epiphysis (probably the lower) of the leg, while the growth in the other epiphyses remains unaffected. Though the causal relation between the paralysis and the retardation of growth is not elucidated, it is certain that it is not due to the vasomotor disturbances, nor can it be entirely due to abnormal mechanical conditions. These observations of Nathan are intesting and should stimulate other observers to make further studies.

Activation of Muscles in Infantile Paralysis.—Feiss [32] makes a plea for the early activation of muscles in infantile paralysis. He would begin immediately, in spite of pain in the muscles, to encourage the patient to move the limbs, and would try to have them stand and walk within a week of the onset. Time is lost and nothing gained, he believes, by two months of recumbency and rest. He reports a case in which the

31. Nathan, P. W.: J. Bone & Joint Surg. **5**:260 (April) 1923.
32. Feiss, H. O.: Ohio State M. J. **19**:177 (March) 1923.

diagnosis of infantile paralysis was made, August 30. "The child could not extend the right knee, but he could extend the left knee with eversion of the leg only. The knee jerks were diminished on the left and absent on the right. The patient could not stand even with support. There was further weakness in the pelvic and thigh muscles and perhaps in the loin and spinal muscles. The child was put on his feet immediately and by September 6 he had learned to stand alone for a few seconds. September 12, he was beginning to walk alone. January 9, he showed both knee jerks present, and at the present time he is practically normal.

[ED. NOTE.—His patients made a good recovery, but no different or more satisfactory than a number of the spontaneous recoveries that we see. The element of fatigue is such an important factor in regarding the progress or even causing actual loss of power in these cases that the method of Feiss seems to be contraindicated. We have seen many cases in which the extent of the paralysis has undoubtedly been increased by too early attempts to use the muscles. From a physiologic point of view, we believe rest is indicated.]

Colloidal Gold Reaction in Acute Poliomyelitis.—Regan and Litvak [33] have made further studies of poliomyelitis, confirming their previous work. In a series of forty-two cases of acute poliomyelitis, in which 132 spinal fluids were examined, a study of the colloidal gold reaction was carried out by Regan and his assistants. There was always a reaction with colloidal gold solution in the case of every poliomyelitic fluid taken during the acute stage of the disease. This reduction was constantly in the same zone—the zone of low dilutions, the so-called syphilitic zone. In 88 per cent. of the spinal fluids examined, the reaction occurred in the first six dilutions between 1.10 and 1.30. In fourteen spinal fluids, the reaction extended to the seventh dilution, 1.640. These patients more or less characteristically presented marked polioneuritic or meningitic symptoms or else pronounced paralysis. In no instance was a normal reaction encountered before the end of the third week of illness. In twenty-three patients, the spinal fluid was examined as late as the eighth week, and fifteen, or 65 per cent., had become normal by that time.

[ED. NOTE.—Regan and Cheney in a previous article have suggested that the end of the inflammatory stage is shown by the return to normal of the gold chlorid reduction. The fact that in a large number of their cases it did not return to normal till after the eighth week is good evidence that physiotherapy should not be started soon after the development of the paralysis.]

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33. Regan, J. C.; Litvak, A., and Regan, C.: Colloidal Gold Reaction in Acute Poliomyelitis, Am. J. Dis. Child. **25**:76 (Jan.) 1923.

A Clinical Study of Thirty Cases of Muscular Dystrophy.—Funsten [34] sums up our knowledge of this disease as follows: 1. The disease is almost never known to be transmitted through the father. 2. The date of onset is important; the earlier the age of onset, the poorer the prognosis. 3. Pes equinus is the most constant contracture. 4. The patient usually loses the power of standing at from 10 to 12 years, and death comes on at from 14 to 18 years. His ergographic records show that a small load could be raised almost indefinitely, but a normal load could not be raised at all. A muscle contraction may be continued every two seconds for five minutes without variation, while in a case of infantile paralysis, though the strength was the same at the start, complete fatigue was present before five minutes passed. The metabolic studies show increased output of creatin in the urine and low sugar tolerance. In summarizing, it seems hard at the present time, whether from the evidence presented by many authors or from his own observations, to draw definite conclusions as to the etiology of the progressive muscular dystrophies. If one allows oneself to be influenced entirely by the theories of endocrine origin, many stumbling blocks are encountered. It is hard to believe that a cystic tumor or other pathologic condition of one of these glands can always locate itself in just the place to cause repeatedly the identical or almost identical clinical entity. The evidence introduced in this respect does not always seem to be entirely sound. On the other hand, the recoveries reported in the literature and in Funsten's own series seem to be beyond question. There is not in progressive muscular dystrophy the low fatigue coefficient, with physiologic limits, that one would expect to find. The muscle fibers which remain unaffected from the disease seem to be acting to the extent of their normal limit. But there seems to be not "enough ammunition to go around." Is it a matter of waste product elimination? Are a part of the muscle fibers in their physiologic capacity of glycogen builders and storehouses, or as secretors of sarcolactic acid and carbon dioxid, failing in their work? The undoubted recovery in some cases encourages the attempt of further study of the etiology.

Transference of the Crest of the Ilium for Flexion-Contracture of the Hip.—Campbell [35] believes that increased lordosis adequately compensates for 45 degrees flexion of the hip, but that flexion of 60 degrees or over renders the leg practically useless. Tenotomy, fasciotomy and myotomy has not given satisfactory results, and Soutter's operation, though giving very gratifying results in almost all cases, does not fully correct a shortening of the abductors. The author has used a modification of the operation in thirty cases, with 100 per cent.

34. Funsten, R. V.: J. Bone & Joint Surg. **5**:190 (April) 1923.
35. Campbell, W. C.: Southern M. J. **16**:289 (April) 1923.

success. Instead of separating the origin of the muscle with periosteum elevator, the whole outer third of the crest of the ilium and the anterior superior spine is chiseled off. This is allowed to slide down nearly to the rim of the acetabulum, where a surface of bone is denuded and the detached crest with its muscle origins is allowed to become fixed. The psoas, fasciae and capsule also may be cut if necessary to accomplish complete extension of the leg.

Osteitis Fibrosa Cystica Occurring in a Flat Bone.—Galvin [36] reports a case of osteitis fibrosa cystica occurring in the jaw of a man, 23 years old. Two and one-half years previously, he had sustained a blow in this region. He sought advice, not on account of pain, but because of a tumor which had been increasing rapidly for two months. The roentgenogram revealed a multilocular cyst containing the fourth molar tooth. At operation the cortex was found to be very thin and the cavities were filled with a brown serous fluid. All the cyst walls were broken down, and a tibial transplant was inserted from the angle of the jaw forward to the anterior limit of the cyst. The end-result in the roentgenogram showed a firm cortex over the original tumor area and an absorption of the graft.

SCOLIOSIS

Forbes [37] recognizes the failure that we have made in the treatment of scoliosis, and the fact that there is still great variance of opinion as to its treatment. The one fact definitely established is the interrelation of side bending and rotation. Side bending in one direction is accompanied by rotation of the vertebrae in the opposite direction. On this fact, our treatment is based. The difference between pathologic and physiologic scoliosis must be recognized and the attempt made to produce physiologic scoliosis, which is the reverse of the pathologic scoliosis already existing. Pressure applied by plaster casts and braces is to be supplemented by exercises strengthening the muscles that should produce this reverse type. The fundamental principle to be followed is the reversal of the deformity, to change the contour of the thorax and trunk, both as a whole and in its parts, so that the function of the thoracic organs is not materially affected. If we fail in maintaining the position of correction, some operation of fusion of the vertebrae should be performed.

The Treatment of Scoliosis.—Schede [38] maintains that the treatment of scoliosis should be based on two principles: (1) general care, which is frequently sufficient in light cases, and (2) a realization of the fundamental danger of faulty weight-bearing. He brings his patient into a

36. Galvin, A. H.: California State J. M. **21**:244 (June) 1923.
37. Forbes, A. M.: Canad. M. A. J. **13**:168 (March) 1923.
38. Schede: Ztschr. f. orthop. Chir. **43**:410, 1923.

position in which weight bearing cannot act harmfully, but on the contrary exerts a correcting influence. The first step is loosening up of the contracted tissue by longitudinal traction, which is modified to make it more bearable and more effective. A well padded plaster collar is adjusted for holding the straps of the head sling. The patient rests on a wooden plane which is mounted on wheels, and traction is accomplished by placing the frame on an inclined plane, the angle of which is gradually increased up to a considerable amount, 30 degrees or more. Thus, considerable mobilization is accomplished within a relatively short time, one or two weeks being sufficient in most cases. Then a low plaster cast is applied in the following manner: The patient with a right dorsal curve, for example, is placed in the standing position with the lumbar spine flexed forward as much as possible and the body bent to the left as far as possible. The plaster encircles the pelvis, is well moulded over the crest and extends on the right side high enough to cover the lower part of the dorsal hump; whereas, on the left side, it reaches only to the iliac crest. Now, when the patient wishes to resume the upright position, he will find himself tending to correct or overcorrect the deformity. At the same time, the spinal and thoracic muscles are not bound as in a high corset, but are forced to be active in order to restore the balance. Breathing and other exercises can be carried out and are prescribed for regular performance. When the correcting force of the cast is exhausted, another one is applied, with more correction if such is possible, and finally a corset is made of steel and leather after the same fashion. This method is not suited to cases which are severe or in which there is contraction.

Stimulated by the observations of cases in which osteoplastic operations had been performed on the thorax in Sauerbruch's clinic, Frey [39] has advanced a new theory of the pathogenesis of scoliosis. Because of constitutional weakness of the muscles and ligaments, or general diseases such as rachitis or late rachitis, severe scolioses may develop. A healthy individual will never acquire a true scoliosis. The primary change takes place at the ribs, which, in Frey's opinion, increase in their curve and impinge on the transverse processes, forcing the dorsal spine into a rotary motion. The lateral curve is only secondary to the rotation. Hence, the rational therapy of severe scoliosis is to loosen the ribs by paravertebral resections, leaving longer pieces on the convex side and only short pieces on the concave side. Only by such a radical procedure is it possible to correct a thorax distorted by severe scoliosis.

[ED. NOTE.—As we have said in commenting on the earlier work of Frey, we believe more work should be done by Frey and his associates before these radical operative procedures are generally employed. We have as yet no satisfactory report of end-results.]

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39. Frey: Zentralbl. f. Chir. Jan. 27, 1923, No. 4, p. 156.

Low Brace for Scoliosis.—Hohmann [40] calls attention to the value of a low back support in severe cases of kyphoscoliosis in which a high corset cannot well be tolerated on account of the pressure on the thorax and interference with the function of the thoracic viscera. Hohmann's brace consists of a well modeled pelvic girdle on which a simple pad is adjusted, preventing the thorax from listing over to the side or backward. He describes two modifications, which are made clear by the illustrations. The same apparatus is used for cases of severe scoliosis after correction by a plaster-of-Paris cast.

[ED. NOTE.—We believe that these low back supports are often of great benefit in stabilizing the lumbar spine, lessening the lordosis and exerting a somewhat corrective influence on the rotation. They may well be employed in early and comparatively light cases as an adjunct to exercise treatment. They definitely favor the maintenance of a corrective posture and lessen muscle fatigue.]

ARTHRITIS AND MYOSITIS

Pemberton, Hendrix and Crouter [41] report the results of their study of the blood gases and the blood flow in cases of chronic arthritis. Observations have been conducted on seventy-seven arthritics and in about forty other cases, representing apparent health and various types of disease. The methods of analysis employed consisted in the study of the oxygen content; the dissociation curves for oxygen and carbon dioxid; the sugar tolerance, and the rate of blood flow in the hands. These were utilized in connection with fasting, resting subjects, and also in connection with the influence of food, exercise, external heat, drugs and other factors. The high incidence of a lowered sugar tolerance in cases of arthritis at large, especially in the more acute stages as already described is corroborated. Observations on the blood gases during the conduction of such a test and after making a brief preliminary use of the tourniquet show that there tends to be a rise in the percentage saturation of the blood for oxygen if the tolerance for glucose is lowered. The average under these conditions of all percentage saturation points, in the thirteen arthritics with a low sugar tolerance, was 78.37 per cent.; in the eight arthritics with normal sugar tolerance, 64.06 per cent., and in the three normal persons with a normal sugar tolerance, 41.81 per cent. The average percentage saturation at fasting level was: for thirteen arthritics with low sugar tolerance, 76.33 per cent.; for eight arthritics with normal sugar tolerance, 64.04 per cent.; for three normal persons with normal sugar tolerance, 40.09

40. Hohmann, G.: München. med. Wchnschr. **70**:177 (Feb. 9) 1923.

41. Pemberton, R.; Hendrix, B. M., and Crouter, C. Y.: J. Metabolic Research **2**:1270 (April 28) 1923.

per cent. An increased saturation of the venous blood implies a decreased saturation of the supplied tissue. Under the conditions of the experiment, the average percentage of saturation for the group of seventy-seven fasting arthritics at all stages of the disease, including advanced convalescence, was higher than it was for twelve fasting normal persons in the ratio of 53.68 to 41.71 per cent. In some arthritics, the saturation figures reached very high values. The range was from 26 to 97 per cent. for arthritics, and from 27 to 51 per cent. for normal persons. This difference in the groups could not be explained on the basis of external temperature, activity, musculature, nutrition or other obvious factors. During convalescence in eight cases which presented high percentage figures for oxygen, the figures fell in six, were essentially unchanged in one and rose in another. The safest interpretation to make of these findings is that the percentage of oxygen in the peripheral venous blood of the fasting arthritics under the conditions described is, on the average, slightly higher than in fasting normals. The tentative conclusion can be advanced that it tends to return to normal with convalescence or recovery in some cases. Study of the dissociation curves of the blood of twelve arthritics for oxygen showed that they fell, in general, within normal limits, with one marked exception. In eight determinations of the carbon dioxid dissociation curves of the blood all but one fell within the normal range. Attempts to correlate a high percentage saturation of oxygen in the venous blood of the arthritic with changes in the rate of blood flow have not substantiated such a conclusion. Thirteen studies on the rate of blood flow in eleven fasting, resting arthritics, as compared with eight determinations on six normal persons under the same conditions, give average figures, which are about the same for the two groups. The rate of blood flow in the fasting arthritics seems to be less constant and may reach lower figures than is the case with fasting normals. Blood studies conducted during a series of seventeen "bakes" on arthritics and normal persons showed that the oxygen percentage rose in fourteen, or 82 per cent., owing chiefly to a rise in the content. In general, the alveolar carbon dioxid fell below normal coincidently with the onset of perspiration, and then rose above normal after the bake. The curve for blood carbon dioxid did not agree well with the curve for alveolar carbon dioxid, but this may have been due to the difficulty of obtaining coincident determinations. The carbon dioxid capacity varied irregularly in the eight cases in which it was studied.

[Ed. Note.—This highly technical article is abstracted because we believe that one of the most important, if not the most important, attacks on chronic arthritis is the biochemical attack. We hope that the authors will in some future article give their results in the different types of chronic arthritis. At least two of these types the editors believe to be pathologic entities.]

Salicylates in Rheumatism.—Salicylates [42] continue to be employed with satisfactory results in a variety of disorders, among which acute rheumatic fever is outstanding in respect to the improvement or relief of patients affected by it. The conditions existing in the living body preclude the possibility, or at any rate render it extremely improbable, that salicylic acid can accumulate in bactericidal quantities in the tissues during life. The antipyretic potency of the salicylates does not account for their beneficial effect in rheumatic arthritis. In an attempt to imitate rheumatic arthritis experimentally in animals, Swift and Boots of the Hospital of the Rockefeller Institute have noticed that rabbits inoculated intravenously with nonhemolytic streptococci, while under the influence of full therapeutic doses of sodium salicylate, developed almost as many inflamed joints as untreated controls similarly inoculated. The rabbits given salicylates, on the other hand, had a much higher proportion of only mildly inflamed joints than did the control. Thus, we stand before the experimentally demonstrated fact that salicylates may modify favorably certain types of inflammation of the joint, while the explanation of this fortunately beneficent result still remains to be ascertained.

Portals of Infection in Arthritis.—Irons [43] recognizes the fact that the removal of tonsils which are suspected of being foci of infection in arthritis may be followed in some cases by an early disappearance of the symptoms of inflammation. There is, however, a group of cases in which such other factors as disturbances of nutrition, family predisposition and the persistence of infection in the joints themselves presumably play an important part in the continuation of the disease. The cases of frank arthritis deformans belong to this class and the removal of chronic infections often fails to give favorable results. The gastro-intestinal tract must be considered as offering a portal of infection. We must consider the permeability of the intestinal wall. Certain experiments on dogs and monkeys give evidence of this. The author has also isolated organisms from the blood in four cases of ulcerative colitis. It should be made clear that instances of this sort are few, compared with the large numbers of metastatic infections of other origin, and that in perhaps the majority of instances in which temporary intestinal symptoms accompany recurrent metastatic infections, they are secondary and incidental. The satisfactory demonstration of direct invasion through the intact intestinal mucosa of man by organisms which can cause arthritis without continued general infection presents

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42. A Study of Salicylates in Rheumatism, Current Comment, J. A. M. A. **80**:1941 (June 30) 1923.

43. Irons, E. E.: Some Less Frequently Considered Portals of Infection in Arthritis and Iritis, J. A. M. A. **80**:1899 (June 30) 1923.

difficulties that, so far, have not been overcome. That the intestinal tract may sometimes be the portal of entry of recurrent metastatic infection seems certain.

Roentgen-Ray Gastro-Intestinal Studies of Patients with Chronic Deforming Arthritis.—Roentgen studies have been made by Taylor [44] of the intestinal tract in cases of chronic deforming arthritis, by giving a single meal, examining the upper tract, and then, at six, nine, eleven and twenty-four hours, making observations with the screen, and thereafter every twenty-four hours until the disposition of the meal is determined. An enema is used if the distal colon is not well visualized. In general, the observations have been that (1) the majority of patients with chronic deforming arthritis have a certain type of colon, characterized typically by its abnormal length and its abnormal mobility; (2) practically all the cases that have become chronic show so-called surgical lesions in the right colon or in the ileum or in both, and (3) these lesions consist of adventitious bands similar to Jackson's membrane, involving the colon, usually above the ileocecal valve, and involving occasionally the ileum, producing the so-called Lane kink and other less typical fixations, or chronic appendicitis, or the results of an acute inflammatory process in the appendix with adhesions to the surrounding structures, notably the ileum and right colon itself (the appendix is frequently retrocecal), or postoperative adhesions following removal of the appendix. As regards treatment, the author says that 50 per cent. of the surgical cases have shown practically complete arrest of the disease. The same conditions are found in patients who do not have arthritis, but do have symptoms which can be most easily explained as being the result of an intestinal infection.

Osteo-Arthritis and Rheumatoid Arthritis.—An interesting discussion [45] of chronic arthritis took place at a meeting of the Fellows of the Royal Society of Medicine, April 23. Garrod, Cassidy and Poynton participated. All recognized the difference between rheumatoid arthritis and osteo-arthritis. Poynton argued for the infectious origin of the diseases, basing his claims on the work he had carried out with Paine. He urged the use of vaccines made from the causative agent when a local focus could be found. The others recognized the occurrence of an infectious type, but thought that metabolic disturbance was the basis of most of the cases of rheumatoid arthritis. Dr. J. A. Glover of the ministry of health presented some interesting figures, the results of the inquiry instituted in 1921 by direction of the chief medical officer, to look into the amount of morbidity among insured persons

44. Taylor, R. G.: Am. J. Roentgenol. **16**:424 (June) 1923.

45. Meeting of Royal Society of Medicine, April, 1923, reported in Brit. M. J., May 5, 1923, p. 760.

ascribed to "rheumatism." By the help of insurance examiners it was possible to keep a sample population of 90,000 persons under review during 1922.

Among a total of 67,635 patients, there were 2,614 whose disease was of a chronic joint nature, rheumatoid arthritis, osteo-arthritis, gout or unclassifiable joint changes, the latter two groups being very small. Insurance practitioners surveying a panel of 90,891 cases reported that, in 1922, 523 persons examined ascribed their morbidity to rheumatism. Dr. Glover's figures seem to show that the female susceptibility to the rheumatoid type was at least three times as great as that of the male, while osteo-arthritis was nearly twice as commonly reported in men as in women.

Atrophic Arthritis.—Swaim [46] uses the classification of infectious, atrophic and hypertrophic arthritis. He says that the infectious group has its origin in the alimentary tract, tonsils, teeth, sinuses, gallbladder, appendix, etc. He feels that his experience has been that the large majority of such cases are intestinal in origin. He believes that the atrophic form is much more common than is usually believed, and that the disease is a more complicated process than simple infection. It is a metabolic disturbance causing certain definite chemical processes in and around the joint. This reaction causes proliferation of soft parts and atrophy of bones and cartilage, the nutrition of bone being so affected that the calcium elements are either not laid down or are destroyed and removed. He points out that in atrophic arthritis there is usually a history of long continued physical or nervous strain which may upset the physiologic balance, particularly of the internal glandular system. The earliest symptom is frequently a "numbness" of the fingers, an actual blanching which extends over the ends of one or several fingers. This may occur at any time. It is usually absent after the process of atrophy is well started. With few exceptions, these cases show low systolic blood pressures, from 105 to 120, with a low pulse pressure ranging from 15 to 30; also a subnormal temperature. There is usually an acid tongue. There will also be general atrophic changes in the skin, hair, fingernails and muscles. The skin is dry and does not perspire. Swaim emphasizes the necessity of differentiating the types of arthritis in order to treat them logically. For the atrophic cases, he says first and foremost, the physiologic condition should be improved. This can best be accomplished by improving the body mechanics. Better chemistry is secured through care in selecting the base-forming mineral salt foods in the diet. Better elimination and neutralization of acid can be hastened not only by base forming foods but by alkalines and lastly by Dr. Wilde's method of skin elimination in his low temperature steam bath.

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46. Swaim, L. T.: Rhode Island M. J. **6**:51 (April) 1923.

Ophthalmia Neonatorum with Joint Metastases.—Di Bella Vito [47] has encountered a case of ophthalmia neonatorum due to gonorrhea, in which there were metastases to the joints. Two days after birth, the child had a high fever, and the following day, swelling in the right eye, with subsequent purulent discharge. A few days later, the other eye was also affected. Eleven days after birth, swelling developed in the left hand. On the fourteenth day after birth, swelling developed in the left foot and in the little finger of the right hand. Exploratory puncture in the region of the ankle gave 1 c.c. of limpid serum, cultures from which showed pure gonococci. Gonococcic vaccine was used and local applications. By the eighteenth day after birth, the affected joints had returned to normal, but others became involved and the injections of vaccine were continued, ten injections being used, at the end of which complete cure was obtained. The joint conditions all cleared up satisfactorily. The author says that in his study of the literature, joint complications in gonococcal ophthalmia are exceedingly rare, though comparatively common in urethritis and vulvovaginitis in young children. He found two cases described by Deutschmann almost identical with the case reported by him; one case reported by Haushalter, and one by Griffon. Clement Lucas in 1899 was able to collect twenty-three cases. A few other cases have been described since. It is evidently a very rare complication.

From his case and from the study of the cases reported, he concludes that, while joint metastases due to gonorrheal infection in adults are very slow and difficult to cure and the joints often become deformed, this is not seemingly the case in the new-born, in whom the condition clears up possibly more or less spontaneously without deformity.

Gonorrheal Infections in Ankylosing Spondylitis.—Ramel [48] is convinced that the gonococcus plays an important part in the production of spondylose rhizomélique, and reports three cases which postively support his contention, in which the gonococci were found in the prostatic secretions. Two clinical types of the disease may be recognized. To the first belong the cases which develop an acute urethritis complicated by arthritis in the four extremities or by a chronic prostatitis. One or two years later, when the patient considers himself cured pain appears in the lumbosacral region, and a progressive ankylosing arthritis develops. In the second type, a history is obtained of several acute attacks of vertebral arthritis associated with other symptoms of gonococcal infection. The spinous processes are tender to palpation and thickened. The fascia covering them shows a porky infiltration. The skin is red, and hot to the touch. Here, we are dealing with a true

47. Di Bella, V.: Pediatria **31**:146 (Feb. 1) 1923.
48. Ramel, Edwin: Ann. d. mal. vén. **18**:177 (March) 1923.

gonococcal arthritis, which goes on to ankylosis. He reports three cases illustrating this classification, in which after repeated efforts it was possible to show the presence of gonococci in the prostate. He urges more careful search for a specific focus during the early stage of the disease, when its eradication may arrest the anklyosing process.

Sacro-Iliac Arthrosis Obliterans.—Blaine [49] found during the routine examination of about 1,800 cases in which the lower spine was affected a group of eighteen which presented unusual changes in the sacro-iliac joints. These patients complained of a dull pain and some soreness and stiffness of the back, with discomfort in the lower spine. There were clinical evidences of spinal rigidity, limitation of motion of the lower part of the back and slight tenderness over the sacro-iliac joints and lower lumbar spine, with occasional obliteration of the normal lumbar curve. The onset was gradual, and the condition very slowly progressive, with the periods of recession of symptoms. The roentgen-ray manifestations were gross intrinsic joint changes in the sacro-iliac synchondroses, generally bilateral, but occasionally unilateral, suggesting a low grade type of joint infection of marked chronicity. Comparison with the normal sacro-iliac joint shadow indicated that early disease in the joint may be deduced by a relative decrease in the sharpness of the joint edges, which appear somewhat hazy in shadow detail, probably owing to localized edema and swelling of the articular surface tissues and the interarticular cartilages, causing the loss of sharp shadow detail. Further advance of disease is manifested by shadows which indicate an erosion of the articular surface edges, normally uniform throughout, and apparent increase in interarticular distance. A still further advance is shown by a material decrease in the interarticular distance between sacrum and ilium because of loss through absorption of interarticular cartilage which has been softened by disease, and which eventually disappears, permitting the two bones to come in contact with each other, easily demonstrated by the roentgenographic shadow. An advanced case will reveal a total obliteration of the involved joint, a synarthrosis resulting, two contiguous bones fusing into a single bone in unilateral cases, and in bilateral involvement the three bones forming a single unit. A reparative process may sometimes be established by shadows that represent a distinct hypertrophy of bone developing around the obliterated joint, often extending into the neighboring soft tissues. The roentgenograms do not establish the cause for this sequence of joint change. A striking feature is that the age in the group in question was always under 30 and sometimes under 25 years. This condition must be distinguished from typhoid arthritis (which it closely

49. Blaine, E. S.: Am. J. Roentgenol. **10**:189 (March) 1923.

resembles in the roentgenographic appearance), free septic arthritis, chronic hypertrophic osteoarthritis and tuberculous arthritis. The last is seldom bilateral.

Arthritis Following Typhus Fever.—Froitzki,[50] working in southern Russia under the most difficult conditions, has had ample opportunity to study complications of typhus fever. They may be divided into the early, middle and late lesions. To the second class belong many affections of the bones and joints. He has observed arthritic changes of the hip, knee, elbow, feet and sacro-iliac joints. A caries of bone also occurs, especially of the ribs and cartilages and of the vertebrae. Caries of the costal cartilages was seen in sixteen cases, one rib usually being affected, resembling an osteomyelitis.

Myositis Ossificans.—Lewis [51] has noticed that cases of circumscribed myositis ossificans have been reported with increasing frequency during the last few years. He carefully describes two cases of circumscribed myositis ossificans developing in clean incised abdominal wounds, which form an interesting study. Myositis ossificans must be differentiated from a number of different lesions, such as hematoma in muscle and muscle callus and interstitial syphilitic processes involving muscle, different forms of tumors of muscle and exostoses. It is especially important to differentiate between malignant growths of bone and myositis ossificans. It may be difficult to differentiate clinically between a periosteal sarcoma and myositis ossificans, for a history of trauma may be elicited in each; both occur in young people, and the consistency may be the same. In some cases, the differential diagnosis cannot be made by the history and physical findings. The roentgen-ray findings are usually so typical that a differential diagnosis is possible, but, if there is any doubt, a histologic examination of the tissue should be made. Amputation should not be considered in any case in which there is any doubt as to the diagnosis until an histologic examination has been made. In the etiology of myositis ossificans, different factors play a rôle. No one theory will explain all cases. Myositis ossificans developing in the abdominal wall in clean incised wounds, when there is no possibility of any injury to periosteum or bone, is due to the metaplasia of connective tissue. Fascia and muscle in contact with acid secretions become converted into bone. It is striking how many cases of myositis ossificans in the abdominal wall have followed operations on the stomach, either a gastro-enterostomy or a resection. Myositis ossificans developing after dislocations is apparently due to periosteal stripping and displacement. The ossifying myositis

50. Froitzki: Russian Monograph, abstr. Zentralorgan f. d. ges. Chir., June 8, 1922, p. 322.

51. Lewis, Dean: Myositis Ossificans, J. A. M. A. **80**:1281 (May 5) 1923.

occurring in fractures associated with considerable movement of the fragments, such as the pathologic fractures occurring in tabes, demonstrates better than any other lesion the rôle played by periosteal stripping and displacement.

Myositis Ossificans Progressive.—Nutt [52] reports a case of myositis ossificans progressiva and makes a complete review of the literature. This is a disease of early life in which the fibrous tissue in and about the muscles changes to bone. It steadily progresses and may eventually render the subject a veritable ossified man. No therapeutic measure is known to retard its progress. It is usually accompanied by defects in the development of the toes or fingers (microdactylia). Studies of the metabolism have failed to show anything abnormal, the blood calcium particularly being normal. Microscopic study of the newly formed and forming bone shows nothing which differs from new bone formation following trauma. There are present hemorrhage, connective tissue hyperplasia about the clot, calcification and ossification. Nutt finds reports of 130 cases in the literature. His own case was in a child of 10, and the condition had first appeared at the age of 1½ years, six months after a fall from a high chair. There had been gradual and steady progress. Examination showed the following muscles to be involved: both sternomastoids, trapezius, complexus, latissimus dorsi, external oblique abdominalis, both pectorals, subscapularis, teres major, biceps, coraco-brachialis and triceps. There was a remarkable ridge of ossification extending obliquely downward from the left nipple, a distance of 3½ inches (8.7 cm.). The adductors of the right leg were completely ossified, and there was also new bone formation in the lower legs. The involved joints showed scarcely any function.

Stiff Hands.—Ciaccia [53] reports an interesting series of cases of rigid hands, dividing them into four groups according to the causes of the rigidity: (1) adhesions in the tendons and muscles in the forearm; (2) prolonged immobilization in splints; (3) changes in the joints themselves, and (4) infections and changes in the tissue of the hand. He advocates various measures of physiotherapy, as hot soaks, hyperemia by Bier and Klapp apparatus, massage, active movements, passive movements by hand or by Zander methods, splints to force the fingers into flexion and traction to force the fingers into extension, also forcible manipulation. The author reports very satisfactory results.

[ED. NOTE.—Ciaccia does not mention the great advantages of traction, first in the line of deformity, flexion being gained thereafter by a continuing of the traction as the immobility is overcome. This is the

52. Nutt, J. J.: J. Bone & Joint Surg. **5**:344 (April) 1923.
53. Ciaccia, S.: Chir. d. org. di movimento, November, 1922, p. 666.

same principle as that employed in overcoming deformities of the hip in tuberculosis by traction in the line of deformity, in altering the line of traction as the deformity is lessened. This method is perhaps the greatest single aid in overcoming rigidity of the fingers that was developed during the recent war. It acts by slowly bringing about a relaxation of the articular and periarticular structures by continuous slow, gradual stretching, which eventually allows function to complete the cure.]

OSTEOMYELITIS

Blood Vessels of the Bones in Relation to Osteomyelitis.—Nussbaum [54] has demonstrated that the terminal arteries in the metaphysis admit emboli over 20 microns in diameter. This explains, he believes, why large bacterial masses can find lodgment here, while they do not remain in the arteries elsewhere in the bones. Smaller emboli are washed along, as the arteries of the epiphysis and diaphysis are not terminal.

Osteomyelitis of the Pelvic Bones.—Bearse [55] calls attention to the fact that while infection of the iliac bone is not common, it is far from rare. When it occurs in children, it is a particularly serious condition, because the diagnosis at first may be difficult. Since the immediate prognosis, prevention of complications and shortening of convalescence depend on early treatment, early diagnosis is essential. The treatment is based on general surgical principles and varies with the condition found. When the bone lesion is adequately drained through a perforation in the cortex, incision of the abscess may be sufficient. If perforation has not taken place, or if the bone drainage is inadequate, trephining is the operation of choice. If the process is diffuse, a partial or total resection of the dead bone should be done, depending on the amount of involvement. Osteomyelitis of the ilium is more common than is generally supposed, and should always be borne in mind in a case of painful hip that permits good motion. The local symptoms are often referred to the hip joint and not to the ilium. The important factor in diagnosis is tenderness over the ilium, without restriction of motion at the hip joint. The roentgen ray is at first of no help, but is later of decided aid. Owing to the structure of the ilium, there is early perforation, and if the disease extends, there are further perforations. While the prognosis in this condition is grave because of proximity to the hip joint and the peritoneal cavity, early recognition and treatment renders it more favorable. Serious complications may arise at any stage of the disease. The treatment is early operation with adequate drainage.

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54. Nussbaum: Zentralbl. f. Chir. **49**:700 (May 20) 1922.

55. Bearse, Carl: Osteomyelitis of Ilium in Children, J. A. M. A. **80**:991 (April 7) 1923.

Levi [56] reports the case of a girl of 15 years who complained of pain in the left buttock and inability to use the leg. In two days, the temperature went to 105 F., with delirium, and there were abdominal symptoms. After about ten days swelling appeared over the external condyle of the right elbow, which was drained, and healed rapidly. During the next two weeks, the left thigh became larger, and when opened below the trochanter showed foul yellow pus. Roentgenographic examination was then made, and a marked suppurative process involving practically the whole of the left side of the pelvis and the sacro-iliac joint was revealed. The writer says that the points of interest are occurrence of symptoms of peritoneal involvement, due probably to leakage of the products of infection through the thin peritoneal lining of the abdominal cavity, and the occurrence of so extensive a process without any history of injury.

Keyes [57] also reports an interesting case of osteomyelitis of the pelvis, involving the pubic bone. For this reason, the simple diagnosis of pelvic abscess was made at a well known clinic, and later a double ovariotomy was performed. When the true condition of destruction of bone was revealed by a later roentgenogram, the cavity in the pubic bone was curetted and later complete recovery took place.

[ED. NOTE.—In one of the previous articles, the excision of the entire ilium is advocated, if the extension of the process seems to demand it. We believe that such a radical operation is likely to be fatal and is inadvisable. We have also been impressed by the fact that many cases of osteomyelitis of the ilium may have their origin in a septic arthritis of the sacro-iliac joint, as in the case reported by Léri.]

NEOPLASMS

Sacrococcygeal Chordoma.—Hirsch and Ingals [58] call attention to a rare neoplasm, the sacrococcygeal chordoma. These tumors arising from the remnants of the notochord are found to occur especially at the base of the skull and in the region of the sacrum. Their occurrence in the latter region makes them of interest to the orthopedic surgeon, although they may not be associated with any subjective symptoms. Sacrococcygeal chordomas, while relatively infrequent, deserve consideration clinically because of their tendency to recur. While practically all reported are malignant, the growth generally remains regional, and remote metastases are infrequent.

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56. Levi, I. P.: Am. J. Roentgenol. **10**:203 (March) 1923.

57. Keyes, A. B.: Osteomyelitis of Crest of Right Pubic Bone, J. A. M. A. **80**:1451 (May 19) 1923.

58. Hirsch, E. F., and Ingals, Mary: Sacrococcygeal Chordoma, J. A. M. A. **80**:1369 (May 12) 1923.

Myeloma of the Vertebrae.—Osgood [59] reports three more cases of multiple myeloma involving the vertebrae, and reviews the pathology of this fatal disease on the basis of the tissue removed in one of his cases. The only practical value of the article is to point out the likelihood of confusing the symptoms and lesions of this rather rare neoplasm with tuberculosis of the spine. Two of his cases had been treated for the latter condition, and in one the patient had been subjected to a vertebral fusion which, of course, did not in any way control the progress of the disease. In another case, although the condition had been suspected, a spontaneous fracture of the thigh was the first conclusive clinical evidence. In only one of his cases were Bence-Jones (albumosuria) bodies found in the urine.

BACKACHE AND SCIATICA

Relation of Sciatica to the Sacro-Iliac Joint.—A review of forty successive cases of sciatica has impressed Cowan [60] with two facts: the great frequency with which sacro-iliac joint pain is found associated with the nerve pain, and the fact that pressure on the sacro-iliac joint in nearly all cases causes acute pain down the course of the nerve, which, with pressure on the joint, is much more severe than the pain caused by local pressure on the painful spots along the course of the nerve. He has been forced to the opinion that some morbid condition in or about the sacro-iliac joint (probably an arthritis or a periarthritis) is usually the cause of the pain in sciatica; further, that the pain is usually neuralgic. There is a close relation between the sacro-iliac joint and the sciatic nerve. Bending or walking cause severe pain in patients with sciatica. Both these actions cause strain on the sacro-iliac joint. Assuming that there is an arthritis of the joint, an exacerbation of pain would be expected. There is almost immediate relief on lying down, especially in the semiprone position, with all the strain removed from the joint. Relief would not be experienced if the trouble were neuritis. Of thirty-eight patients, only three showed neither signs nor symptoms in the sacro-iliac joint; thirty-two gave a positive response down the nerve to pressure on the joint, and of these twenty-seven were improved by treatment of the joint. In twelve of fourteen cases of less than six months' duration, there was pain in the joint as well as down the course of the nerve. In only nine cases of twenty-four of more than six months' duration was there pain in the joint. Treatment directed toward the sacro-iliac joint instead of toward the course of the nerve has given most striking results, which could not have been obtained if the joint had not been the cause of the pain.

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59. Osgood, R. B.: Boston M. & S. J. **188**:380 (March 22) 1923.
60. Cowan, John: Brit. M. J. **1**:372 (March 3) 1923.

Abnormalities of the Fifth Lumbar Transverse Processes Associated with Sciatic Pain.—Moore [61] reports a series of nine cases of sciatic pain, in all of which abnormalities of the transverse process of the last lumbar vertebra, with impingement on the sacrum or ilium were present. In seven of these he operated, and in six, he removed the transverse process, either completely or partially, while in one he contented himself with removing only that portion of the ilium which was in contact with the transverse process. All the patients made prompt recoveries, the sciatic pain in several disappearing at the end of three to four days, while in others it persisted not more than two weeks. All had what was apparently true sciatic scoliosis of long standing, which had resisted other orthopedic treatment. Those patients that he had been able to follow up had remained well. Of the two patients not operated on, one recovered promptly following tonsillectomy, while the other showed complete obliteration of the sacro-iliac joint, and he did not consider operation advisable. His operative procedure was as follows: A skin incision about 6 inches (15 cm.) long was made over the posterior portion of the crest of the ilium, which was exposed. The lumbar and gluteal muscles were then stripped subperiosteally from this portion of the crest. A segment of bone about 2 inches (5 cm.) long and 1 inch (2.5 cm.) wide was cut from the ilium and removed. This gave an easier approach to the process, and at the same time removed the portion of the ilium impinged on by the process. The latter was thus freed from its ligamentous attachments and removed with an osteotome. None of the patients were put in plaster or braces and they were gotten out of bed in from ten to fourteen days. Back bending exercises were begun as soon as they could be done with comfort.

[Ed. Note.—Although these cases of Moore seem to have been very fortunate in their outcome, we counsel very careful selection of cases for this radical operation, which is not without danger. In a large clinic where these abnormalities are frequently encountered, it has been found possible to relieve symptoms by supportive or postural treatment. These conditions undoubtedly represent potential causes of pain, but we must remember that they have existed for many years without the potential pain becoming actual.]

STATIC CONDITIONS

Faulty Body Mechanics in Childhood.—Wilson [62] discusses the three types of anatomy as described by Bean and Goldthwait. He suggests that the term "normal" be differentiated from the term "mechanically

61. Moore, B. H.: J. Bone & Joint Surg. **5**:212 (April) 1923.
62. Wilson, J. C.: California State J. Med. **21**:145 (April) 1923.

perfect." Bryant's work is also quoted, and he considers it reasonable to believe that an elongated mesentery is detrimental to the transmission of impulses along the sympathetic trunks, which physiologists tell us plays an important part in digestion. In regard to the poorly nourished child, he says that improvement in the nutrition will have little effect on improper attitude unless mechanical measures are utilized to overcome the muscular contractures and improve the atonic muscle groups. He mentions seventeen cases sent to the posture clinic at the Children's Hospital in Los Angeles for the correction of faulty body mechanics which were under observation for an average of 45.7 days. There was an average gain in weight of 1.07 ounces (51 gm.) per day as against 0.23 ounce (6.9 gm.) for control children of corresponding weights and heights. In addition to the postural exercises, a thirty minute rest period each day was prescribed. The use of mechanical appliances in children with faulty mechanics should be generally discouraged, and if employed they should represent only a temporary feature of the treatment.

Faulty Posture as a Cause of Obscure Digestive and Nutritional Disorders.—Nicholson [63] recognizes two etiologic factors in faulty posture: (1) congenital; (2) acquired. In the congenital class are all the cases of malformation and also a goodly number of cases of children of tall slender build. They have congenitally poor bodily mechanics which do not necessarily cause but certainly predispose to poor posture. In the group of acquired poor postures are many cases of difficult feeding during infancy and early childhood in infants whose powers of digestion were poor or whose feeding management was not what it should have been. These are malnutrition cases. Nicholson has become convinced that although correction of poor bodily mechanics takes time and patience, it will clear up many obscure conditions. It is important to examine all children with special reference to posture when they have poor appetites, tire easily, are constipated, irritable and undernourished.

Importance of Correct Furniture.—Goldthwait [64] calls attention to the importance of correct furniture in schools, colleges and industrial plants. He describes the types of chairs and desks which were constructed on the recommendation of medical committees for Smith College and the Massachusetts Institute of Technology. The most important essential is to prevent buckling of the body at the waist line and to render it possible to maintain an erect sitting posture without fatigue. For this, a shallow, flat seat is required, so that the body rocks forward on the ischial tuberosities without transferring the weight

63. Nicholson, P.: Pennsylvania M. J. **26**:296 (Feb.) 1923.
64. Goldthwait, J. E.: J. Bone & Joint Surg. **5**:179 (April) 1923.

to the back of the thighs. It is also essential that the desk or arm pallette for writing be placed at the proper level and slanted upward so that the visual focal distance remains constant and there is no tendency to droop the head when writing at the top of the page.

TENDON, BONE AND JOINT SURGERY

Tendon Transplantation.—In dealing with injuries of the peripheral nerves, Johnstone [65] has found paralysis of the intrinsic muscles of the hand resulting from combined lesions of the median and ulnar nerves one of the most difficult of all conditions to treat. Time and experience have shown that the result of suture of these nerves is only a fair return of sensibility in the hand and fingers and recovery of voluntary power in most of the extrinsic muscles of the limb. This leaves the patient with a very crippling disability, due to the inability to oppose the thumb to the other fingers, especially to the index finger. Hitherto no satisfactory method of treatment existed, but Johnstone now reports that he has succeeded in relieving the condition in two cases by employing a form of tendon transplantation recently described by Ney. Ney's operation has already been reported in one of the previous Reports of Progress and consists of the transplantation of the palmaris longus, or, in its absence, of the tendon of the flexor carpi radialis, into the tendon of the paralyzed flexor brevis pollicis. Johnstone used the flexor carpi radialis in both his cases, first cutting it free from its insertion and then passing it upward to the flexor brevis pollicis tendon, where it was firmly attached. The suture was performed with the thumb in the position of opposition and following closure a plaster splint was applied, holding the wrist slightly flexed and the thumb opposed. Johnstone advised this procedure not only as a permanent tendon transplantation but also as a method of posturizing the paralyzed opponens muscle in its relapsed position, in the hope that this muscle will in due course return to voluntary power.

Fielitz [66] reports a case of paralysis of the deltoid muscle in a young man of 17 years which he treated by transplanting the whole of the pectoralis major muscle into the deltoid, with a remarkable result. Active movement of the arm is possible in all directions, with a very considerable amount of power.

[Ed. Note.—It is obvious from the two foregoing reports that the field for the development of new operations for tendon transplantation is still far from exhausted. No more satisfactory results are recorded anywhere than those following tendon transference in cases of irreparable injury of the musculospiral nerve. From the nature of

65. Johnstone, J. G.: Bone & Joint Surg. **5**:278 (April) 1923.
66. Fielitz: Zentralbl. f. Chir., March 10, 1923, p. 419.

things, the upper extremity, where ability to perform certain movements is at a premium, lends itself to the procedure more readily than the lower extremity, where the necessity of bearing the body weight imposes heavy strain and demands stability above all. It is unfortuntae that the details of the operation performed by Fielitz are not available, but one of the editors reports that he personally has seen this case and that the result was in all respects satisfactory.]

Operation for the Relief of Flexion Contractures of the Forearm.—Page [67] describes an operation which he has devised for the relief of obstinate flexion contractures of the forearm. Thus far, he has employed it in six cases of varied etiology, three due to ulnar nerve palsy, one to ischemic paralysis, one to monoplegia and one to hemiplegia. The immediate results are described as satisfactory and superior to those obtained by the operations of tendon lengthening or bone shortening, the only procedures hitherto used. Sufficient time has not yet elapsed to judge of the final results. His operation is designed to displace the points of origin of the contracted muscles downward. An incision is made over the inner side of the elbow, extending from 3 inches (7.5 cm.) above the internal epicondyle to about the junction of the middle and lower thirds of the forearm. The ulnar nerve is exposed, freed and retracted forward out of harm's way. The attachments of the whole group of flexor muscles of the forearm are detached subperiosteally from the humerus and stripped away from the internal lateral ligament of the elbow (the joint is usually opened). The aponeurosis attached to the ulna is then divided throughout its entire length and the muscle mass thus loosened is elevated, exposing the attachment of the brachialis anticus. If the flexor longus pollicis is also included, the stripping process is carried across the interosseous space and this muscle raised from its attachment to the front of the radius. Lastly, the bicipital fascia is cut through if it appears to offer any resistance to the descent of the muscles. The whole muscle mass is displaced downward until full correction is obtained, usually a distance of about 1 inch (2.5 cm.). The skin is sutured and the hand splinted in the corrected position. Voluntary control of the muscles is at first lost, or becomes very weak for a time, and is then gradually recovered.

[Ed. Note.—We shall await with interest a later report of the end-results in these cases. Page's operation seems logical, and if the dangers of nerve injury and vascular damage from operative trauma can be eliminated, it would seem to possess a great advantage over the procedures of tendon lengthening and bone shortening, in that it leaves the neuromuscular mechanism intact and ready to function at a compara-

67. Page, C. M.: J. Bone & Joint Surg. **5**:233 (April) 1923.

tively early date. Certainly, there are few surgeons of experience who approach this condition with enthusiasm, especially when it is the result of ischemic paralysis. If tendon lengthening is to be performed, practically all of the flexor tendons must be treated in order to obtain correction. This means an extensive operation and there is danger that considerable stiffness may result from scar formation and tendon adhesion. The operation of bone shortening seems an even more heroic procedure, though it has been followed by many good results. We should question the advisability of applying this new operative procedure in cases of flexion contracture resulting from spastic paralysis as Page has done. We are afraid that the benefits here will prove as fleeting as those resulting from tenotomy alone. Stëffel's method of neurotomy or an operation for tendon transference by which the weakened muscles are reinforced by the transplantation of tendons from the overacting side more nearly satisfies our view of rational treatment.]

Dupuytren's Contraction.—Tubby,[68] discussing the subject of Dupuytren's contraction, describes his own operation, which consists in making parallel incisions over the prominent bands and then carefully dissecting out all the fibrous tissue, going down into the fingers as far as necessary. The wound is then swabbed out with fibrolysin and some of this material is injected into the tissues around the wound and beneath the healthy skin. From ten to seventeen days is required for healing, but after the first week, the fingers may be gently moved every other day. He believes the condition is due to a fibrositis of the palmar fascia.

Mayer[69] explains the frequent recurrences after operation for congenital wry neck by the incomplete immobilization of the head. In his opinion, it is not sufficient to fix only the cervical spine, but the whole spine should be immobilized. Following the operation, a plaster cast is applied over the pelvis and thorax, and as soon as the patient begins to awaken from the anesthetic he is placed in the sitting position and the head fixed in the overcorrected position by the addition of a plaster helmet.

[Ed. Note.—We agree with Mayer that plaster fixation when employed should include not only the neck and shoulders, but the whole spine. The sight of a small child with its shoulders and neck bowed forward under the weight of a heavy plaster helmet and shoulder piece constitutes an unhappy spectacle for those with an orthopedic conscience. Solid support can only be obtained by using the pelvis as the foundation. We confess to a certain amount of surprise at the frequency with which Mayer has encountered recurrence of deformity following operative

68. Tubby, A. H.: Practitioner **110**:214 (March) 1923.
69. Mayer: Zentralbl. f. Chir., Feb. 24, 1923, p. 322.

correction. Sever, from an end result study of the operative treatment of this condition in a large series of cases at the Children's Hospital, Boston, found recurrence of the deformity very infrequent and the results satisfactory in over 90 per cent. of the cases.]

Rupture of Long Head of Biceps Flexor Cubiti Muscle.—Ludington [70] reports a case of rupture of the long head of the biceps of which he had made a careful study. A man of 56 suddenly experienced pain in the shoulder and upper arm while lifting a heavy box. He was able to continue at his work, but later the pain increased and he became disabled. He was examined fourteen weeks later, when there was a distinctly palpable and faintly audible creak in the shoulder and a point of tenderness just under the acromion. There was limitation of voluntary abduction, circumduction and backward extension. The belly of the biceps when contracted was soft and the attempt voluntarily to abduct the arm revealed a slight hollow on the anterior surface of the shoulder immediately below and parallel to the anterior border of the deltoid. Ludington here describes a new diagnostic test which proved positive in this case and should be helpful in others. The patient is asked to abduct the arms and place the hands on the top of the head with the fingers interlocked, a position in which there is maximum relaxation of the biceps and its long head. The examiner then places two fingers on the tendon of the biceps, which can be clearly felt, and requests the patient to contract this muscle. Absence of contraction of the long head was clearly demonstrated in the reported case. Operation was performed eighty-five days after injury, and the tendon was found torn two-fifths across at its point of origin. Adhesions were found in the groove and the proximal portion of the tendon was resected and the distal stump inserted in the short head and sutured. The after-treatment consisted of fixation for fourteen days, followed by active and passive movement. Complete recovery followed, and the patient was performing full manual labor at the end of fourteen weeks. In discussing the condition in the light of a study of the literature, Ludington points out that the cases are either of spontaneous or traumatic etiology and that rupture may occur inside or outside the groove. Rupture within the groove is nearly always spontaneous, and is usually associated with chronic arthritis. Ledderhouse found that in 50 per cent. of cadavers of persons of moderately advanced age there was evidence of arthritis. Both he and Ewald agree that in the region of the shoulder the exostoses appear first and most prominently about the tuberosities and along the bicipital groove. Bercher explains the sequence of events leading up to rupture as, first, the appearance of osteophytes, in the beginning smooth and rounded, later becoming spiculated. As a result

70. Ludington, N. H.: Ann. Surg. **77**:358 (March) 1923.

of this process, the tendon either becomes imprisoned in a bony tunnel or dislodged from its bed, and in either case it may chafe, fray out and rupture. In the traumatic cases, the rupture always occurs outside the groove and usually above the groove or adjacent to its point of origin, though there have been a few cases of rupture below the groove. In explaining the mechanism of traumatic rupture, Ludington points out that when a weight is being lifted with the arm well away from the side, the long tendon is free from the humeral head and the tubercles most nearly approach the glenoid rim. As the body straightens up and the arm swings down, the tuberosities rotate away from the glenoid and the tendon of the biceps is angulated over the head of the humerus, the latter acting as a lever with a mechanical advantage of 51 to 1, and thus putting the tendon under great strain. If there is present in the tendon or its sheath any condition which impedes its free passage through the intertubercular notch, rupture is favored, and this constitutes a predisposing cause. Unfortunately, with our present clinical knowledge, there is little possibility of being able to differentiate the various types of rupture or to do more than recognize its occurrence. Regardless of the site of rupture, Ludington considers operation to be the proper treatment. The disability otherwise remains permanent, while excellent results have been reported in all cases in which operation has been performed, no matter whether this was done a few days or four years after the onset of the disability.

[Ed. Note.—Pain in the region of the shoulder is a common complaint, and differentiation of the various conditions which may be responsible for it is often difficult, especially when the roentgen-ray examination is negative. Doubtless, because of its convenience, the diagnosis of subacromial or subdeltoid bursitis is often abused. Ludington's case is of interest as showing how easily such a definite lesion as rupture of the tendon of the biceps may be overlooked, and we consider the new diagnostic test which he suggests as probably valuable.]

Congenital Radio-Ulnar Synostosis.—Gibson [71] discusses the subject of congenital radio-ulnar synostosis with special reference to the value of operative treatment. The results reported in the literature are distinctly discouraging, and in practically every instance operation has been followed by a new formation of callus and recurrence of the condition to a greater or less extent. Moreover, from his own study and a personal experience with two cases, Gibson concludes that, though the condition represents a disability, it does not constitute an insuperable handicap, nor does it prevent a patient from earning his living. Compensation for loss of rotation in the forearm is provided

71. Gibson, Alexander: J. Bone & Joint Surg. **5**:279 (April) 1923.

by greater flexibility of the wrist joint. Most of these cases are ankylosed in the position of full pronation, which is not the optimum one from the standpoint of function. When this is the case, osteotomy to obtain the mid-position between supination and pronation, the more useful position, may be worth while, but this is the only operative procedure which he considers at all justifiable.

[ED. NOTE.—This opinion is deserving of attention, as coming from a surgeon.]

Arthrodesis of the Shoulder Joint.—Rokitzki,[72] dissatisfied with the frequent failures following ankylosing operations on the shoulder joint, has devised a new method. His technic is as follows: With the patient in the lateral position and with the arm held in right angle abduction, an incision is made beginning at the humerus, following the edge of the latissimus dorsi to a point 2 inches (5 cm.) below the lower corner of the scapula, and reaching 1 inch (2.5 cm.) inward from that point. The tendon of the latissimus is split three-quarters inch (1.9 cm.); the periosteum elevated, and a hole drilled into the bone as far as the marrow. The lateral margin of the scapula is then exposed, and a piece of bone 2 cm. wide is split off with the bone scissors and chisel from its border. A bone graft is thus formed, and its lower end carrying the angle of the scapula is trimmed and inserted in the hole in the humerus, while the upper end is fitted against the cut edge of the scapula just below the neck. In this way, a bony bridge or prop is formed, securely holding the arm in full abduction. The author claims that his method has the advantage of taking into account and preventing the loss of position which so frequently follows arthrodesing operations which attack only the articular surfaces of the joint.

[ED. NOTE.—It would seem that Rokitzki's procedure, while satisfying the mechanical requirements, might fail to achieve its object in a considerable number of cases, owing to absorption and fracture of the graft. The actual contact between the graft and living bone is small, while the distance spanned is considerable, conditions which are not favorable for a successful result. On the other hand, if combined with an actual arthrodesis of the joint proper, it is quite conceivable that this procedure might provide an excellent method of internally splinting the bones while ankylosis was occurring, and in that case it would be immaterial whether the graft survived or disappeared.]

Prevision in Cuneiform Osteotomy.—Cadenat[73] recommends that more exact methods be used in the correction of crooked limbs by cuneiform osteotomy. The size of the wedge to be removed should be exactly measured. He constructs a card pattern which is made from

72. Rokitzki: Verhandl. d. Chir. Pirogoff Gesellsch., 1921; abstr. Zentralbl. f. d. ges. Chir., June 8, 1922, p. 380.

73. Cadenat, F. M.: Rev. d'orthopédie, January, 1923, p. 61.

tracings of the roentgenograms. The angle of the wedge is equal to the angle of duration of the line of the leg. The wedge may be of a single type with quadrilateral sides, or it may be made with the saw at an angle, in which case the sides of the wedge will not be made parallel. In any case, the exact size and shape of the wedge should be represented by the model. He has constructed a form of compass that may be used in constructing the model and in mapping out the shape of the wedge at the time of operation.

Hallux Valgus.—Silver[74] describes the operation which he has devised for the correction of hallux valgus. Thus far he has performed forty-nine such operations in thirty-one cases, and satisfactory results have been obtained in all but two cases. In the latter, partial relapses were noted, one due to the wearing of short shoes and the other the result of incomplete correction at the time of operation. He considers the results much better as regards both form and function than those obtained by other operations which he has employed. Many of the usual procedures correct the pathologic condition, but do not overcome the deformity. For this, it is necessary to offset the structural shortening of the tissues on the outer side of the joint, including the external lateral ligament and the joint capsule, and to tighten the relaxed capsule on the inner side of the joint, at the same time restoring normal muscle balance by replacing the displaced flexor and extensor tendons and their sesamoids. He makes the usual curved incision with convexity downward; the bursa is dissected out, and the capsule exposed. In the latter, a Y-shaped incision is now made, forming three flaps; the first a U-shaped flap with its base attached to the mesial surface of the proximal portion of the phalanx and superior and inferior flaps posterior to this. The exostosis is then shaved off and the bony edges rounded. The next step is to pass an osteotome through the joint until it is in contact with the external lateral ligament, and by this means to cut a flap in the external portion of the capsule of rectangular shape, with its base attached to the metatarsal. This cuts the shortened structures and allows complete correction of the deformity to be obtained, with replacement of the flexor and extensor tendons together with the sesamoids at the inner side of the joint. The toe is then held in extreme overcorrection (45 per cent. abduction), and the flaps closed on the inner side of the joint. The U-shaped flap is pulled backward as far as necessary to retain the position, and sutures are placed in its upper and lower margins passing through the dorsal and plantar flaps. The latter are then sutured together over it. Aluminum splints are applied to hold the toes in proper position. Emphasis is placed on careful after-treatment. After a few days, a bias flannel bandage is applied and reapplied daily

74. Silver, David: J. Bone & Joint Surg. **5**:225 (April) 1923.

in the form of a spica, holding the great toe abducted and compressing the anterior arch. At the end of one week, walking on the outer border of the feet is encouraged, and a shoe of proper last is permitted after from three to four weeks. At this time, the splint is removed and a spica adhesive strapping substituted to reinforce the internal lateral ligament. A laced anterior arch cuff is also used. A short course of intensive training in the proper use of the feet is also given.

[ED. NOTE.—We have had no experience with Silver's operation and must therefore refrain from comment, beyond saying that the procedure is based on careful reasoning and appears rational. Many operations have been devised for this condition, and a study of the end-results would seem to show that, with the exception of certain procedures which excise the head of the metatarsal, the securing of good results seems to be more a matter of nontraumatizing technic and careful after-treatment than of type of operation. Certainly, the carefully detailed plan of after-treatment which Silver outlines is to be commended.]

Bone Grafting and Bone Regeneration.—Christophe [75] reports a case of homogeneous bone transplantation. The patient, a soldier, had sustained a gunshot wound of the knee, which shattered the patella. Four months later, a patella taken from another soldier, and which had been kept in alcohol for three days, was implanted, and the functional results were perfect. Experimental investigation with grafts kept in alcohol is described and additional clinical experiences all justify the assumption that a bone placed at once in alcohol and used soon afterward offers ideal material for grafts. It can be fitted exactly to the defect and permits movement of the part at once, thus averting atrophy of muscles. The dead bone is not absorbed as rapidly as living bone, but otherwise the reparative process is identical. Either the graft is tolerated and heals in place or it is absorbed and new bone is formed.

DISLOCATIONS

Congenital Dislocation of the Hip.—Loeffler,[76] discussing the treatment of old congenital dislocations of the hip, states that open reduction is indicated in cases showing insurmountable obstacles, such as incarceration of the capsule, up to the sixth year. From the seventh to the fourteenth year, open reduction should be considered when the head stands not higher than 3 or 4 cm. above the acetabulum and can be brought down with fair ease, but where closed reduction cannot be effected. Beyond the fourteenth year, the choice of the method depends on the amount of shortening, firmness of the head, subjective disturbances, limitation of action and endurance in walking. In old cases,

75. Christophe, L.: Arch. Franco-belges de chir. **26**:13 (Jan.) 1923.
76. Loeffler: Zentralbl. f. Chir., March 10, 1923, p. 419.

preliminary nail or wire traction on the condyles or the trochanter may be of value, and tenotomy of the iliopsoas may be indicated. For open reduction, it is necessary to preserve at least one layer of cartilage. This is accomplished by shaping the roof of the acetabulum and the lower part of the head, leaving the other cartilaginous surfaces intact. Tenotomies of the adductor and hamstring muscles may be necessary. Open reduction is prone to grave dangers, such as infection and ankylosis. Even necrosis of the reduced head has been seen by Loeffler and others. In most of the late cases, the radical operation will not be possible and symptomatic relief must be sought. Loeffler cites the various methods at hand, of which he prefers Lorenz' bifurcation operation, subtrochanteric osteotomy, with placing of the lower fragment in the acetabulum. Payr and his assistant have used wire traction on the trochanter in a very obstinate case, and by this means have been able to reduce the hip of a 17-year-old girl who had a shortening of 6 cm.

Old Unreduced Obturater Dislocations of the Hip.—Watkins [77] discusses in an interesting and comprehensive fashion the subject of old long-standing unreduced obturator dislocations and their treatment. His investigation was inspired by a case of his own, which is reported in full. He found reports of seventeen similar cases in the literature. Of these, six had been treated by resection, and in one an osteotomy had been performed. Twice reduction was accomplished only after the inner wall of the socket had been cut away. Of the eight patients who underwent reduction, one child recovered complete function, one adult recovered partial motion and the remaining six developed ankylosis. There were three deaths. A majority of the cases were first transformed manually into iliac dislocations and then operation was performed. Watkins considered this a very damaging procedure and one of the causes of failure. The usual hip incisions are unsatisfactory for this condition, as they expose only the acetabulum, whereas the head is located in the obturator foramen, and it is this region which must be exposed in order that the restricting bands may be cut. After considerable study, Watkins employed a modification of the Dollinger incision, beginning a finger's breadth to the mesial side of the anterior superior iliac spine and passing downward to the inner side of the sartorius, a distance of from 5 to 6 inches (12.5 to 15 cm.). The sartorius and rectus were retracted to the outer side. The incision was then prolonged laterally, with a right angular limb, which permitted transverse division of the fascia lata (this structure constituting a hindrance to reduction). The capsule was opened and the ringlike constriction about the neck divided. The trochanter was then exposed through a lateral incision, seized with a Lane forceps, and pulled outward, while the usual manipulation of flexion with traction and rotation was attempted. This was

77. Watkins, J. T.: J. Bone & Joint Surg. **5**:243 (April) 1923.

unsuccessful. Further search revealed another tense band of capsule across the neck, and when this was divided reduction occurred almost spontaneously. After closure, a plaster spica was applied and left on for six weeks. At this time, a short spica was applied and weight bearing permitted. Fixation was discontinued at the end of eight weeks. Motion returned slowly and at last report, seven months after operation, there was active flexion of 20 degrees, 15 of abduction, and 15 of rotation. Watkins believes this to be the first case of an old obturator dislocation which has been reduced without either first transforming it into a posterior dislocation, performing osteotomy or removing a portion of the acetabulum.

Dorsal Dislocation of the Metacarpophalangeal Joint.—Sonntag [78] describes two cases of dorsal dislocation of the metacarpophalangeal joint which he has treated by open reduction, reposition by the closed method being impossible. The joint was opened by an incision 2 cm. long, placed to the radial side of the extensor tendon. The articular capsule was incarcerated, covering the head of the metacarpal bone like a hat. Only after the capsule had been incised on the palmar aspect from the same wound was reduction possible. The incision was closed in three layers, capsule, extensor apparatus and skin. The finger was immobilized for a short time in semiflexion and a good functional result reported.

Open Reduction of Old Luxations of the Shoulder.—Bazy [79] reports an operative procedure which he has used for the reduction of old, long-standing antero-internal dislocations of the shoulder. The incision is a long anterior one, with a right angle extension at the top in the inward direction, like an inverted L. The coracoid process is temporarily resected and the subscapularis muscle divided, contraction of the latter muscle constituting the main obstacle to reduction. Fixation of the head in the glenoid is obtained by suturing the border of the subcapularis to the glenoid ligament and reattaching the muscle to the lesser tuberosity.

FRACTURES

Colles' Fracture Reversed.—Payne [80] reports a case of a reversed Colles fracture and discusses the condition. It results from a fall on the dorsum of the hand, with violent palmar flexion of the wrist. Tension is exerted on the dorsal ligament of the wrist, and the posterior wall of the radius gives way first, followed by the cancellous bone and the anterior wall, and a displacement results that is exactly the reverse of a typical Colles fracture. The fragments may be impacted or extensively comminuted. The condition is exceedingly rare. In the case

78. Sonntag: Deutsch. med. Wchnschr. **49**:382 (March 23) 1923.
79. Bazy, L.: J. de chir. **21**:145 (Feb.) 1923.
80. Payne, M. I.: Internat. J. Surg., March, 1923.

reported, the displacement consisted almost of a right angle deformity, the lower end of the upper fragment making such pressure under the skin that penetration seemed imminent. Reduction was accomplished by manipulation in the reverse direction to that employed in Colles fracture, hyperflexion being first used to unlock the fragments, followed by traction and hyperextension, and direct pressure to force the fragments into position.

Open Reduction of Fractures of the Forearm.—Lawrence [81] urges the immediate open operative treatment of fractures of the bones of the forearm. He advances the argument that by closed methods many bad results are obtained and that if open treatment is finally adopted it is only after much time has been wasted in the trial of various other methods, and then operation must be performed under conditions that are far from favorable for the best results. He advises that operations on the forearm be performed with the patient lying face down on the table and with the arm flexed and resting on a second table. This position provides an easy and natural exposure of the back of the forearm where the incisions are to be placed, and facilitates manipulation and retention.

On the other hand, Lambotte,[82] writing on the subject of the operative treatment of fractures in general, urges that the intervention be delayed for one or two weeks or even longer. This period of waiting prolongs the disability time by so much, but on the other hand the ultimate result is improved. In a group of fractures of both bones of the leg numbering several hundred, healing was complete within a month in the cases in which this policy of waiting had been followed. At the end of twelve weeks, the periosteum is thickened and congested and sustains less damage from the manipulation attending the application of metal bands or plates than it does when the operation is performed earlier. In the case of injury to the nerves or to the vessels the intervention should, of course, take place earlier.

Fractures of the Upper End of the Humerus.—Sever,[83] discussing the subject of fractures of the upper end of the humerus, urges that these injuries be treated by traction with the arm in the abducted and externally rotated position. It is only in this way that bony union perpetuating false anatomic relations between the fragments can be prevented, and good function restored. He employs an aeroplane splint, which is shaped to maintain the arm in the proper position, and considers that this method of splinting obtains results which are quite equal to those obtained by treatment in bed, with the great advantage that recumbency is avoided. He believes that if this method is followed,

81. Lawrence, J.: J. d. pract. Arsnk. u. Wundarzunk, Nov. 13, 1922, p. 763.
82. Lambotte, A.: Arch. Franco-belges de chir. **26**:57 (Jan.) 1923.
83. Sever, J. W.: Rational Treatment of Fractures of Upper End of Humerus, J. A. M. A. **80**:1603 (June 2) 1923.

open operation for the purpose of securing alinement will be unnecessary, except in certain cases of fracture dislocation.

[ED. NOTE.—We agree with Sever that better functional results in these cases may be obtained if treatment by traction with the arm abducted and externally rotated is employed. We would, in addition, urge that reduction be more carefully controlled and that roentgenograms be made not only in the anteroposterior plane, but also through the axilla. The latter is a fairly new method, and by this means we have seen a very gross deformity revealed, which was entirely unsuspected when roentgen-ray examination was made only in the anteroposterior plane.]

Traction Fracture of the Lesser Trochanter.—Langdon [84] reports a case of separation of the epiphysis of the lesser trochanter. The violence was purely muscular, the injury occurring when the patient was running, and inability actively to flex the thigh was the predominate symptom. Treatment consists of immobilizing the hip by the application of a plaster spica with the thigh in the position of right angle flexion. Only twenty-four such cases have thus far been reported in the literature, and perfect function was restored in practically all.

[ED. NOTE.—One of the editors has recently seen a case which in all respects is identical to the one reported by Langdon, and it is probable that this injury will be found of more frequent occurrence if looked for. The roentgen-ray examination should be made with the leg externally rotated in order to uncover the lesser trochanter.]

Fracture of the Spine of the Tibia.—Stephens [85] reports a case of fracture of the tibial spine and reviews the literature on this subject. He concludes that while the condition is unusual, it is not so rare as one would suppose from a study of the records. It is usually produced by severe traumatism of a twisting variety and is frequently associated with a rupture of the crucial ligaments, traction by the latter on the spine probably constituting the mechanism of the fracture. Conservative treatment is usually successful in recent cases and occasionally in old cases. If there is blocking of extension, operation to remove the interfering fragment is usually indicated. The final results are excellent in all cases; for if conservative treatment does not give a perfect recovery, this goal may be obtained by operation.

Separation of the Upper Epiphysis of the Tibia.—Gibson [86] reports a case of separation of the upper epiphysis of the tibia in a boy of 14, whose leg had been caught in the wheel of a plough. The epiphysis

84. Langdon, J. F.: Surg. Gynec. & Obst. **36**:556 (April) 1923.

85. Stephens, R.: Fracture of Spine of Tibia, J. A. M. A. **80**:905 (March 31) 1923.

86. Gibson, Alexander: Ann. Surg. **77**:485 (April) 1923.

was displaced forward and laterally. Open reduction was required, and it was found quite easy to replace the parts, but extremely difficult to hold them in alinement, and this was only possible when the knee was flexed 30 degrees. Fixation was accomplished by suspending the leg from a cradle with a plaster cuff about the calf, by means of which extension was applied to the upper end of the tibia in a forward and upward direction. Only twenty-five of these cases have thus far been recorded.

Fractures of the Os Calcis.—Becker [87] recommends that operative treatment be employed in reducing fractures of the os calcis, and describes his own method, which is somewhat similar to the one described by Cotton and Wilson, which it antedates by two years. The operation is performed from ten to fourteen days after the injury and in the following manner: A horizontal incision is made one half inch (1.3 cm.) below the level of the external malleolus, and through this an instrument is passed toward the inner side of the ankle. At the point on the inner surface where it is felt beneath the skin, a second incision is made and the instrument is pushed through. With this as a tractor, the fragments are pulled downward and the restoration of the arch of the foot becomes evident at once. An electric drill is then inserted at the lowest point of the posterior process of the os calcis and passed obliquely forward and upward into the body of the bone, the length of the tunnel and its direction having first been determined by measurement of the roentgenogram. Instead of removing the drill and inserting a nail, a procedure which endangers the position of the fragments, the drill is left in place and the wounds closed. The drill is removed at the end of six weeks, and any periosteal overgrowth on the plantar surface chiseled away by a second operation.

Magnuson [88] describes the operation which he has employed to relieve diasability in old fractures of the os calcis. Cotton reported that there was partial disability in 90 per cent. of these cases, and Magnuson finds it present in all, the difficulty being caused by a displacement outward of the posterior fragment, a widening of the heel, pronation of the foot, and painful callus behind the external malleolus. Magnuson's operation, which he has performed in eighteen cases, resembles that of Cotton. A curved incision is made over the outer surface of the os calcis, and the peroneal tendons are freed and retracted downward. The callus is then completely removed with the chisel, care being used to avoid leaving any rough edges. An important part of the procedure is the subsequent wrenching of the foot into a varus position. Considerable force is required and must be applied with the

87. Becker, E.: Zentralbl. f. Chir., Feb. 17, 1923.

88. Magnuson, P. B.: Operation for Relief of Disability in Old Fractures of Os Calcis, J. A. M. A. **80**:1511 (May 26) 1923.

Thomas wrench. Plaster fixation is employed and this is followed by the use of broad shoes with tilted heels and arch pads, which must be worn for some time. By this means, relief may be obtained from a disability that otherwise would be a permanent handicap.

Fracture of the Os Trigonum.—Yerson [89] reports the case of a workman who jumped down from a cart and turned his ankle, the foot being forcibly inverted. Severe pain was felt in the ankle, and later swelling developed. A painful spot on the external malleolus suggested a crack, but the roentgenogram showed a fracture of the os trigonum. Massage and active exercise quickly brought about recovery.

Osteomyelitis in a Closed Fracture.—Watkins [90] cites a case which is of considerable interest in its bearing on the possibility of infection developing in a simple fracture. The patient sustained a fracture of both bones of the forearm in the lower third. At the time of injury, he was suffering from furunculosis in the region of the knee and ankle, and although it was not possible to secure satisfactory reposition of the bones by the closed method, open reduction was wisely withheld because of the fear that infection might develop. As a matter of fact, a hematogenous infection of the fractured bones did develop two months after injury in spite of the fact that no open operation was performed. Culture revealed the same organism as was present in the furuncles.

AMPUTATIONS

Amputation at the Shoulder.—Parakh [91] publishes a method of amputation of the shoulder which was new to him at the time he first tried it, but which he later found had been previously reported. He makes a large flap, commencing at the clavicle near the sternomastoid attachment, and continues the incision along the axillary border of the scapula down to its angle. The muscles attached to the scapula are divided, and this allows the whole extremity to fall forward of its own weight. Little difficulty is then experienced in getting at and ligating the deep vessels; which is in marked contrast to the method of dividing the clavicle and ligating the vessels as the first step. The operation was performed for a rapidly growing endosteal sarcoma of the upper end of the humerus and required only fifty minutes.

D'Agata [92] describes a method used by him and adapted from that of Putti for a cineplastic amputation of the forearm at the junction of the middle and lower thirds in a case of severe tuberculosis of the hand which had resisted a long period of conservative treatment. He separated the two bone stumps so as to make a stump of two pincers

89. Yerson: Rev. suisse d. accid. du travail **16**:273, 1922.
90. Watkins, A.: J. Arkansas M. Soc. J. **19**:145 (Jan.) 1923.
91. Parakh, F. R.: Brit. M. J. **1**:46 (March 17) 1923.
92. D'Agata, Giuseppe: Chir. d. org. di movimento **7**:104 (Jan.) 1923.

attaching the muscles, as required, to the bone ends. By rotary movements of the forearm, the patient can separate or approximate the bone ends so as to hold a pencil, a spoon, etc., between them. Also the action of rotation is used to activate a cineplastic prosthesis so that at will the patient can open and close the fingers.

Two Kineplastic Problems Solved.—Arana, Valle and Wildermuth,[93] at Buenos Aires, are continuing their efforts to render the kineplastic amputation practical. They now report a solution of a difficulty experienced in a case of double amputation of the forearms. They constructed in each arm a kineplastic motor, consisting of the supinator and pronator teres muscles, employing Sauerbruch's technic. At a second operation, a plastic operation was performed and a large eye constructed beneath the motor in order to provide a means of attachment. It has been a long-standing rule in kineplastic procedures to avoid the construction of motors at the level of the articulations because of the likelihood of mechanical interference with movement. In the reported case, this rule had been violated and the motor had been situated in the flexure of the elbow. It proved potentially powerful, with a run of 4 cm. and a strength of 15 kg. The next problem was the construction of the prosthesis, and this was solved by obtaining the hands from the Rizzoli Institute and making the rest of the apparatus in the orthopedic workshop of the Assistance Public at Buenos Aires. Difficulty was now encountered in harnessing the motor, as it proved that the center of flexion of the apparatus did not correspond to the center of the motor, with the result that, when the elbow was flexed, the tractor cord loosened even though the motor remained contracted. After trial of many devices to obviate this difficulty, a solution was finally found in a sliding valve arrangement situated near the wrist, by means of which, as the elbow flexed, the hand was pushed away from the motor a sufficient distance to allow the tractor cord to retain its desired tension. This worked very satisfactorily, and active control of flexion of the fingers by means of the motor was obtained in both the positions of flexion and extension. The patient has already developed the ability to use his hands in a very useful way.

[Ed. Note.—We are happy to record every additional step in the development and perfecting of the kineplastic amputation, but the protracted labor which was required before the problem presented by this particular case could be solved should also serve as a warning against the undertaking of these cases without full realization of the difficulties which are likely to intervene between the moment of operation and the final practical realization of the desired result.]

93. Arana, G. B.; del Valle, D., and Wildermuth, F.: Surg., Gynec. & Obst. **36**:559 (April) 1923.

Plaster Pylon in China.—Van Gorder,[94] writing on the subject of amputations in China, states that this operation is performed very frequently there because of the high incidence of joint tuberculosis, gangrene and severe infections, and the impossibility of being able to carry out prolonged conservative treatment. The absence of artificial limb factories in China and the great expense associated with importing appliances from Europe and America have rendered the after-treatment of patients with amputated limbs a difficult problem. Van Gorder has found that the plaster pylon offers a practical solution of the difficulty. This form of apparatus is quickly and easily made, the necessary materials are always available, and it is inexpensive, and at the same time effective and durable. He believes that some form of apparatus should be supplied to every person whose leg has been amputated, before he leaves the hospital, and in his own experience, the plaster plyon has proved the most satisfactory all round method.

MISCELLANEOUS

Coxa Plana (Legg-Calvé Disease).—Waldenström [95] describes four stages in the development and healing of "coxa plana essentialis." 1. Evolutionary period, from three to four years: (*a*) Initial stage, one half to one year. At the start, there is only limping, without any change in the roentgenogram. After some time, the epiphysis becomes denser, patchy, flatter and uneven at the margin. The articular cartilage is of normal thickness. Attenuations are often seen in the neck close to the epiphyseal line. Sometimes, these are seen before the epiphyseal changes appear. (*b*) Fragmentation stage, from two to three years. The previously dense patches in the epiphysis become denser and the areas between them poorer in lime salts. The epiphysis is thus divided into pieces—often three—which may then become divided further into a mass of small granules. The fragments of the epiphysis become poor in lime salts. The epiphysis becomes flatter and flatter. Sometimes, it is so thin and lacking in calcification that it is scarcely to be seen. Even the joint cartilage becomes thinned. The upper portion of the neck disappears and the fragment of the epiphysis is pressed out on its upper part. In this way, the epiphysis can extend outward to the greater trochanter. The epiphyseal line then becomes more irregular. 2. Healing period, from one to two years. The epiphysis becomes homogeneous again, and the lime salts begin to return. The convex surface (the joint surface) becomes level; the head becomes half moon shaped, and the neck becomes broader in its medial portion. 3. The growing period. This lasts until the growth is finished. During this time, the head attains its definite form and this period is distinguished by normal

94. Van Gorder, G.: China M. J. **37**:1 (Jan.) 1923.
95. Waldenström, H.: Acta chir. Scandinav. **55**:577 (April 11) 1923.

growth and ossification taking place in the deformed hip joint. 4. The definite stage. This is attained when the growth is concluded. The definite form of the joint is, however, usually reached already at the beginning of the growing period. The author also touches on the differential diagnosis between "coxa plana essentialis" and tuberculous ostitis. He holds, in regard to the treatment, that there really is no indication for anything but symptomatic treatment. No athletics or gymnastics should be allowed; the hip should be favored. Cases with acute symptoms should be treated by traction for a period of weeks. The author's treated and untreated cases show practically no difference in end-results.

[ED. NOTE.—This article represents a careful study covering a period of sixteen years. During this time, the author has followed forty cases. Our impression is that although functional cure is common, anatomic cure is rare. The head and neck in the cases we have observed seldom completely regain normal contours and the affected hip is a little more subject to strain.]

Uffreduzzi,[96] from a study of numerous cases of hip conditions, arrives at the following conclusions in regard to infantile deforming osteochondritis, juvenile deforming osteo-arthritis and coxa plana. 1. Infantile osteochondritis (the disease of Legg, Perthes, Calvé and Sourdat, and the coxa plana of Waldenstroem) is an inflammatory affection, most probably of infective origin, of the superior epiphysis of the femur, which develops in the period of infantile growth. 2. The characteristic pathologic-anatomic features are still little known, but it is essentially a retrogressive change in the epiphysis which undergoes a profound alteration in its surroundings and in its structure. The osseous nucleus becomes fragmented. The surrounding parts (the neck, the epiphyseal cartilage and the acetabulum) present changes of varying intensity, due to reaction. 3. The roentgenologic features are the fragmentation of the epiphyseal osseous nucleus into various small nuclei of varying positions, forms and number, accompanied by deformity of the head in the sense of flattening. The neck presents alteration in the structure. 4. The clinical features are analogous to those of a coxitis of a benign course. 5. Juvenile deforming osteoarthritis is an inflammatory affection most probably of an infective origin of the superior epiphysis of the femur in the period of adolescence and youth. 6. The initial pathologic-anatomic features are the result of absorption and cartilaginous metaplasia of the bony trabeculae, with consequent alterations of the superimposed cartilage. 7. Roentgenologic findings are essentially in accord with the lesions. Marginal osteophytic proliferations come secondarily. The earliest lesions are very slightly evident in the roentgenogram. 8. The clinical features are characterized

96. Uffreduzzi, O.: Chir. d. org. di movimento, April, 1923, p. 149.

essentially by the onset of pain and increase in functional incapacity in joints previously without pain and nearly or quite normally able to function. 9. Coxa plana is a title which indicates the alterations in the form of the femoral head in the sense of flattening, which is often the final deformity of an osteochondritis which has gone on to cure, with ossification of the epiphysis. It also can be produced by other affections of varying nature. 10. Infantile osteochondritis, juvenile deforming osteo-arthritis and coxa plana are conditions which often pass successively from one to the other and are perhaps the stages of a single malady.

Jansen [97] proposes an interesting explanation of the developmental changes seen in the neck of the femur in Legg-Calvé's disease and resulting in coxa plana. He believes that these are secondary growth changes due to the efforts of nature to correct an incongruity of the opposing articular surfaces, and that the primary cause is to be found in the hip socket, which is either wide, owing to ischium varum, or too shallow, because of an abnormal thickening of the socket floor. In both cases, the socket is flattened, and the stress of weight bearing is transmitted chiefly to the top of the head rather than evenly distributed throughout its circumference. There is decreased pressure on the lateral portion of the growth disk and increased pressure on the mesial portion. It is well known that increase of pressure may lead to decrease of growth and decrease of pressure to increase of growth, and previous studies by Jansen have shown that this is particularly likely to occur in subjects whose power of growth has been enfeebled by some injury that has befallen them either before or after birth. He has also shown that, apart from growth changes, bone which has already formed, when submitted to undue weight bearing, may absorb lime salts and become plastic. These conditions are present with a flattened socket, and therefore the shortening and thickening of the femoral neck and the flattening of the head may result from this excessive pressure. The growth disk is displaced laterally in response to mechanical stresses, and as the femoral neck grows wider and thicker, it is spread out over an ever enlarging area; which may account for the rents which develop in it or the segmentation of the osseous center. As to the etiology, the theory of an infection is contraverted by the healthy appearance of the patients, the small amount of pain and absence of fever, and chiefly by the absence of reflex stiffness. Also the theory of infection cannot explain the thickness of the socket floor or the ischium varum which Jansen has always found present. As for the ultimate cause of the flattened socket, Jansen favors the view that too small an amniotic sac plays a part. This would also explain the frequency with which the condition is associated with congenital dislocation of the hip, if

97. Jansen, Murk: J. Bone & Joint Surg. **5**:265 (April) 1923.

Le Damany's theory is accepted that here there is a small amniotic sac which causes excessive flexion of the hip and lifts the femoral head out of the socket, the pelvic border acting as fulcrum. In the case of flattened socket, there may be less pressure from the amniotic sac and decrease in the pressure of the head against the socket floor, which normally causes it to deepen; or again a small amniotic sac may be drawn too tight over the ischia, causing them to bend inward, or if the pelvis is lying asymmetrically only one of the ischia may be affected. Jansen classifies coxa plana as one of the malformations brought about by too small an amniotic sac.

Ludloff [98] has found, in operating in a case of so-called Legg-Perthes disease, that the peculiar changes in that case were caused by an osteitis fibrosa, which is probably due to some constitutional anomaly of the endocrine system. He reminds us that he has described a similar case of bilateral affection as early as 1910. He also calls attention to the fact that, in his case, as probably in many others, the so-called slipping of the head from the neck as it appears on the roentgenogram is not a real one, but only the expression of the deforming process of the epiphysis.

Function of the Muscles in Coxa Vara and Valga.—Stimulated by Lange, Bragard [99] has constructed a wooden model for analyzing the mechanism of the gluteus medius and minimus in coxa vara and coxa valga. The insufficient action of these muscles in abduction of the leg and in steadying the pelvis in cases of congenital dislocation of the hip and in coxa vara is at once obvious, but in cases of coxa valga it has not yet been quite well understood. Bragard comes to the conclusion that the latter phenomenon is to be explained by the direction of the abductor muscles in relation to the femur. In coxa valga, the muscles pull in an almost straight direction under very difficult conditions for the point of view of leverage; whereas in coxa vara, the leverage conditions are good, but the abductor muscles are too short to exert sufficient strength. For that same reason, Lange and Lexer, instead of performing an osteotomy, shift the point of insertion of the abductors downward, if they are not too much contracted.

Rubin [100] calls attention to the fact that although pain in the shoulders is associated, as a rule, with disorders of the shoulder joint and of structures in its proximity, various intrathoracic and subdiaphragmatic lesions, such as angina pectoris, pleurisy, pneumonia, new

98. Ludloff: Ztschr. f. orthop. Chir. **44**:101, 1923.

99. Bragard: Ztschr. f. orthop. Chir. **43**:401, 1923.

100. Rubin, I. C.: Sudden Acute Pain in Shoulders Associated with Acute Pelvic Pain in Women, Symptom of Ruptured Ectopic Pregnancy, Indicating Subphrenic Blood Extravasation (Subphrenic Hemoperitoneum), J. A. M. A. **80**:1050 (April 14) 1923.

growths and lesions of the gallbladder, stomach and intestine, may also give rise to pain referred to the shoulders. If gas under the diaphragm can cause shoulder pains by distention and stretching, it may also be assumed that fluid suddenly accumulated in the subphrenic space may also produce these referred pains. It is therefore not surprising to encounter shoulder pain in cases of ruptured ectopic pregnancy, when large quantities of fluid blood are extravasated in the peritoneal cavity and extend upward along the lumbar gutters as high as the subphrenic spaces. The author reports two cases of severe pain in the shoulder in which operation revealed extravasated blood from ruptured tubes. In suspected twisted ovarian cysts, torsion of the tubes or acute inflammatory pelvic lesions, the presence of shoulder pains should suggest ruptured ectopic pregnancy.

Limp of Childhood.—Nutter,[101] in a concise summary, has described the principal distinguishing symptoms of the various conditions that may be the cause of limp in children. The author considers the spine, hip, knee and foot under the various conditions of pathologic changes, and describes the methods of examination for detecting these different lesions.

Study of Gaits.—Lowman [102] believes that the study of gaits should receive more attention, especially after operations to correct deformity. The surgeon should encourage and teach the patient to give up the tendency to walk as before with the old limp and stimulate him to try to walk normally. By careful training in the gymnasium, the limp will improve and the patient develop a new way of walking. Great attention should be paid to the shoe, the proper height of sole and heel, the curve of the sole and the position of the heel. Little changes in these are described which will often greatly lessen the awkardness of a gait.

Elephantiasis.—A study of this condition has been made at Rochester, Minn. Experimental work on dogs was done to see whether the condition could be induced by the injection of pathogenic bacteria. The results were wholly negative. Mahon's [103] conclusions are: 1. The characteristic feature of elephantiasis is an hypertrophy of the collagenous connective tissue with some degree of lymph stasis. 2. The hypertrophy of the connective tissue and the corresponding stasis are probably the result of repeated insults from pathogenic bacteria. 3. In one group of cases of elephantiasis, there is an outward manifestation of infection, evidenced by erythema and adenitis. This type is more common. There is a second group in which the disease develops insidiously, and without any local manifestation of infection. From pathologic study of these cases, the author is convinced that they too

101. Nutter, J. A.: Canadian M. A. J. **13**:182 (March) 1923.
102. Lowman, C. L.: J. Bone & Joint Surg. **5**:185 (April) 1923.
103. Mahon, G. D.: Am. J. M. Sc. **165**:875 (June) 1923.

have an infectious basis which is confined to the lower layers of the subcutaneous tissue and of such low grade as not to excite any local symptoms. 4. Anything that causes venous stasis can be considered a predisposing factor in the development of elephantiasis. 5. Central blockage of the lymphatics probably cannot produce permanent peripheral lymphatic stasis. 6. The parent worm of filaria may excite inflammatory changes and elephantiasis may be produced in such cases by pathogenic bacteria, the filaria being the predisposing factor. 7. In the Kondoleon operation (cutting a section out of the aponeurosis of the thigh and a lesser one out of the subcutaneous tissue, thereby giving a chance for the lymph to drain to the deeper tissues) we have a means of rendering useful service to patients with elephantiasis, although the operation does not positively cure the disease.

BOOK REVIEW

POST-GRADUATE LECTURES DELIVERED BEFORE THE FELLOWSHIP OF MEDICINE AT THE HOUSE OF THE ROYAL SOCIETY OF MEDICINE. John Bale Sons and Danielson, Ltd., Oxford House, London, 1922.

Two lectures in this interesting volume are written by Mr. W. H. Trethowan, F.R.C.S. The first is on disabilities of the feet, due to static or mechanical causes. The lecture is most inclusive and discursive, and hardly lends itself to abstract. All the main causes of static disability are discussed and their treatment outlined. Mr. Trethowan evidently believes that support of the long arch is the sheet anchor of treatment in static disability, especially in women, and that heels should be fairly high and shanks stiff and high arched, or the shoe fitted with carefully fashioned arch supports. There is comparatively little said about foot exercises or an attempt to restore the foot to normal strength and weight bearing ability. We admit that convention often foils this attempt, but in this country most of us are not ready to abandon it nor to depend upon the equinus position to relieve long arch strain, threatening as it is to the integrity of the transverse anterior arch. The second lecture is entitled, "Deformities and Disabilities of the Feet, Due to Paralysis." The advice given concerning the care of poliomyelitis cases seems to us most sound. It includes a careful description of many types of tendon transplantation operations and the rationale of these procedures. Certain of the operations mentioned have not been entirely successful in America, but the general rules laid down are excellent, and show that a very careful selection of cases is made. An important point which is stressed is that tendon transplantation should be undertaken only to prevent the recurrence of a deformity which can be passively fully corrected before the operation is performed, that is, the method should not be employed as a correcting influence. Mr. Trethowan prefers arthrodesing operations and tendon transplantation to astragalectomy for the correction of these paralytic disabilities.

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SUPPURATION IN THE POSTERIOR MEDIASTINUM

WITH REPORT OF CASES

WILLIAM LERCHE, M.D.

ST. PAUL

The division of the mediastinum by French and German anatomists into an anterior and a posterior, the trachea forming the partition between them, has been adopted in this paper for descriptive purposes.

In four cases of acute suppuration of the posterior mediastinum that have come under my observation, the focus of infection was in the neck, and there was extension into the mediastinum. For that reason, I wish to review briefly the arrangement of certain parts of the deep cervical fascia (Fig. 1).

The pretracheal fascia covers the trachea in front and blends laterally with the sheath of the vessels of the neck. In front of this fascia are the sternothyroid, the sternohyoid and the omohyoid muscles, and the space between this fascia and the muscles is the previsceral space of Henke. The prevertebral fascia, covering the bodies of the vertebrae and muscles attached to the spine, joins the sheath of the vessels laterally and forms the posterior wall of the retrovisceral space of Henke. The anterior wall of this space is formed by the thin retro-esophageal fascia and the esophagus. This fascia is a continuation of the buccopharyngeal, and it blends laterally with the sheath of the vessels. The name retro-esophageal fascia is employed by me for descriptive purposes as it is more convenient to give this fascia a specific name than to speak of it as a continuation of the buccopharyngeal fascia. The retrovisceral space is continuous with the retropharyngeal space above and the posterior mediastinum below, so that the space extends from the base of the skull to the diaphragm. Between the retro-esophageal and the pretracheal fasciae is the visceral space containing the esophagus, the trachea and the thyroid gland. The entire space between the pretracheal and the prevertebral fasciae is sometimes called the visceral space; but it seems most confusing to describe a retrovisceral space within the visceral space: hence, the foregoing description.

The experimental demonstration of the various spaces in the neck was first made by the French anatomist Bichat,[1] by injecting air or water with the object of determining the course taken by the pus in

1. Bichat: Anatomie générale **1**, Paris, 1801.

case of suppuration in the neck. Later, Henke,[2] König,[3] Soltmann,[4] Poulsen[5] and others made similar experiments, either injecting water and freezing the cadaver before dissecting, or injecting glue and dissecting after hardening. Schmitt[6] used a solution of rosin in alcohol, to which was added wheat flour and coloring matter. By injecting the pretracheal space, it was found that the mass entered the anterior mediastinum. The injection of the retrovisceral space was made by Schmitt through the base of the skull. When moderate force was employed in injecting the liquid mass, the results were uniform in a number of cadavers (Fig. 2). The injected mass filled the space from the

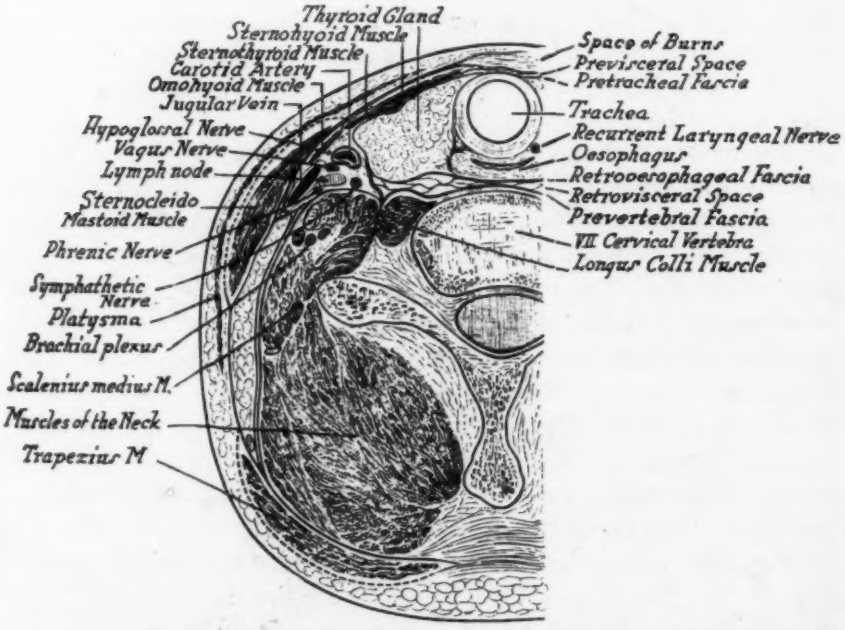

Fig. 1.—Cross-section of the neck through the first tracheal ring (modified after Merkel).

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2. Henke, J. W.: Beiträge zur Anatomie des Menschen, mit. Beziehung aut Bewegung **1,** 1872.

3. König and Riedel: Die entzüdlichen Processe am Hals, Deutsch. Chir. Part 36, 1882.

4. Soltmann: Die Ausbreitungsbezirke der Congestionabscesse bei der Spondylarthrocace der Kinder. Ein anatomische Studie, Jahrb. f. Kinderh., New Series **7,** 1874.

5. Poulsen: Ueber die Fascien und interfascialen Räume am Halse, Deutsch. Ztschr. f. Chir., 1886.

6. Schmitt, Adolf: Die Fascienscheiden und ihre Beziehungen zu Senkungsabscessen. Eine anatomisch-klinische Studie, München., 1893.

base of the skull to the sixth dorsal vertebra; and laterally, to the sheath of the vessels. Anteriorly, the mass was behind the esophagus as far as the junction of the neck with the thorax. The thoracic part of the esophagus was invariably surrounded by the injected mass, and was separated from the trachea in the upper part of the thorax; while the

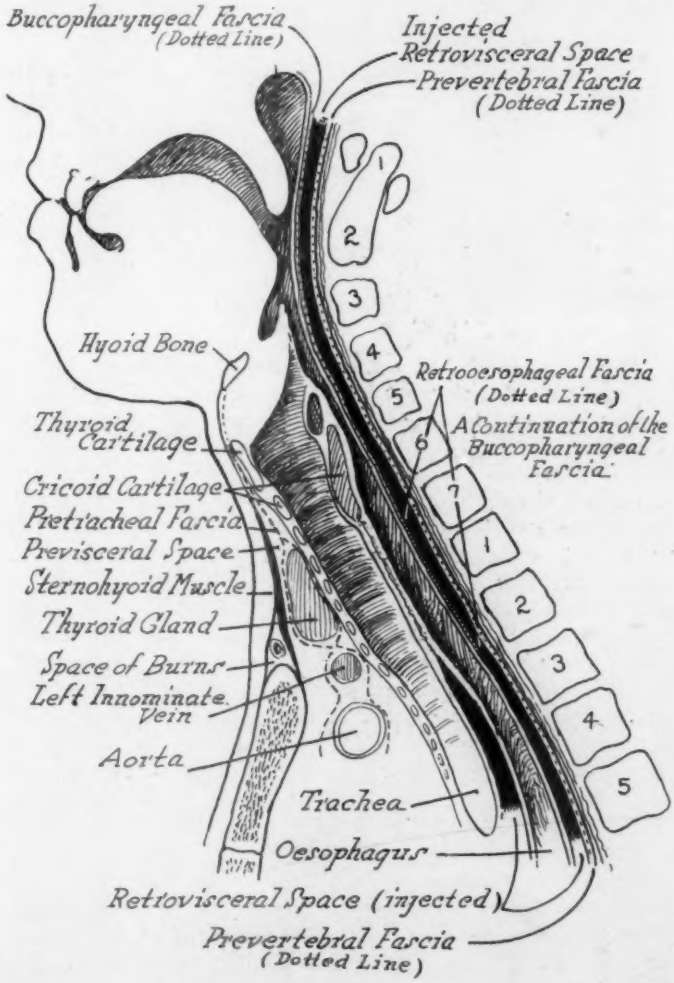

Fig. 2.—Author's illustration of the deep cervical fascia relative to the spaces referred to in the text. The retrovisceral space is injected.

lower end of the trachea and its bifurcation was in the posterior mediastinum, and surrounded by the mass. The injected mass nowhere in its course entered the visceral or the previsceral spaces or the anterior mediastinum. Schmitt says, however, that at the lower end of the trachea and its bifurcation, where it is free in the posterior

mediastinum, there may possibly be an avenue by which pus can enter from one to the other. Although the pus in acute suppuration may take any course, if necrosis destroys the natural boundaries, it probably, in most instances, follows the direction of least resistance; that is, the paths indicated by the experiments. I have injected a barium mixture into the visceral space in cadavers and demonstrated the injected mass in the posterior mediastinum by roentgenogram and dissection.

I think that the observations of Schmitt's are of interest to the surgeon. When an acute suppuration in the visceral or retrovisceral spaces has extended into the posterior mediastinum, the shortest route by which to reach the abscess and drain the cavity lies through the lower cervical region. Through an incision along the inner border of the sternocleidomastoid muscle down to the sternal notch, access to the lower cervical part of the esophagus is gained. By following the lateral aspect of the esophagus, the finger readily enters the posterior mediastinum.

REPORT OF CASES

CASE 1.—A man, aged 30, had a slight attack of sore throat, April 15, 1921, and a more severe attack, one week later. On admission to the hospital, April 23, the throat was found tender to touch, inflamed and somewhat edematous. The lungs were negative. April 24, the patient was very restless and irrational. He complained of pain in the back of the head, difficulty in swallowing, sore throat and cough. The right side of the neck was swollen and painful. Diagnosis of retropharyngeal abscess had been made. April 27, he could take liquids well. April 30, a diagnosis of pneumonia was made.

I saw the patient, May 9, about two weeks after onset. The temperature had varied between 99 and 104 F. The patient had been more or less irrational all the time. Respiration was embarrassed. Roentgenograms of the chest revealed a large shadow in the upper right chest cavity, extending down the right middle area (Fig. 3). There was also involvement of the right lower lobe. Diagnosis of posterior mediastinal abscess was made and operation performed immediately, the posterior mediastinum being entered through the incision described above in the lower cervical region. A large quantity of pus escaped. Two soft rubber catheters were introduced, reaching the bottom of the cavity. Regular irrigation was carried out, first with saline solution, later with surgical solution of chlorinated soda (Dakin's solution).

The patient was fairly comfortable the following day, but on the second day facial erysipelas developed and bulging of the right eye. He again became irrational, and died four days after the operation. Cultures from the abscess showed *Streptococcus pyogenes*. The patient had difficulty in swallowing up to April 27, but after that he could take liquids well. In all probability, the retropharyngeal abscess on that day entered the posterior mediastinum, thus relieving the tension in the hypopharynx.

Necropsy could not be obtained. The abscess started in the retropharyngeal lymph nodes which drain the upper part of the pharynx.

CASE 2.—G. B., man, aged 56, had been troubled with sour stomach for several years. On two occasions he had vomited blood and had had tarry stools. For three years, he had had some difficulty in swallowing. Food and slime would be regurgitated at times. His dysphagia was increasing. The patient was very anemic.

Fig. 3 (Case 1).—Large mediastinal abscess. The roentgenogram is reversed, the abscess being on the right side.

Fig. 4 (Case 2).—Diverticulum of the esophagus filled with barium mixture.

Esophagoscopic examination revealed a small diverticulum in the upper end of the esophagus, which was also demonstrated by roentgenogram (Fig. 4).

Under local anesthesia, the usual esophagotomy incision was made on the left side, and the diverticulum invaginated and obliterated by rows of purse string sutures. A cigaret drain was inserted and the wound was closed. When,

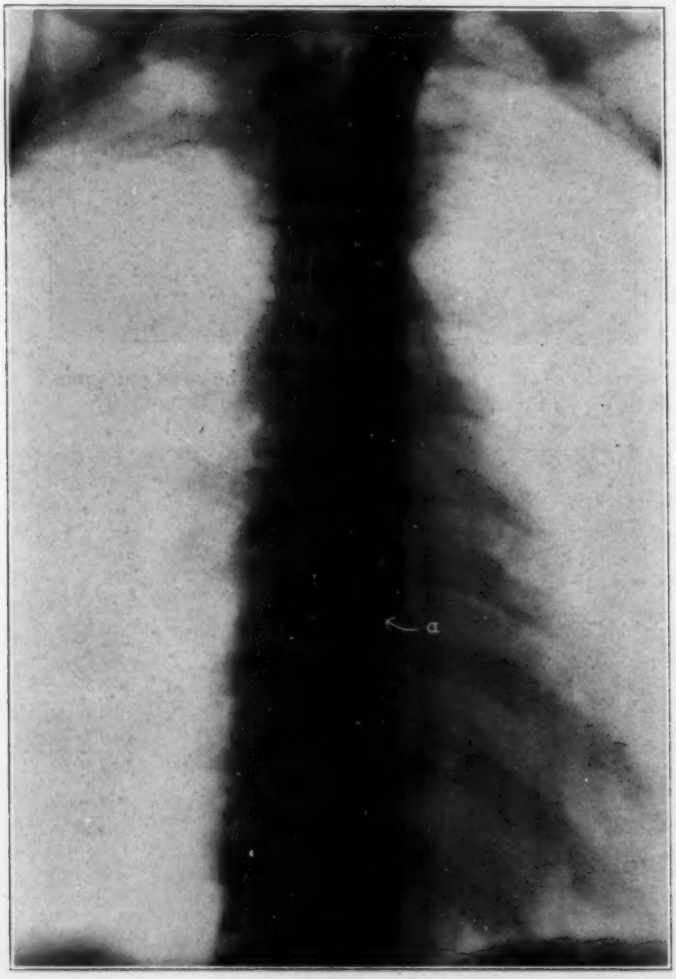

Fig. 5 (Case 2).—Two rubber tubes extending to the bottom of the mediastinal abscess at lower border of eighth thoracic vertebra (*a*).

two days later, the dressing was changed and the drain removed, thin pus welled up. The wound was laid entirely open and it was found that the suppurative process had extended into the posterior mediastinum. Cultures showed *Staphylococcus pyogenes-aureus*. Two soft rubber tubes were introduced into the mediastinum, and surgical solution of chlorinated soda was used at regular intervals (Fig. 5).

The patient made a good recovery. A few weeks later, I made a posterior gastro-enterostomy. He had a large indurated ulcer of the duodenum encroaching on the pylorus, and he was therefore advised to return later for resection of the ulcer.

I have reported this following case before, but will briefly review it with the other cases, particularly on account of its etiology.

CASE 3.—Mrs. R. T., aged 50, had for six years had a brassy cough that frequently became paroxysmal in character. For the same length of time, she

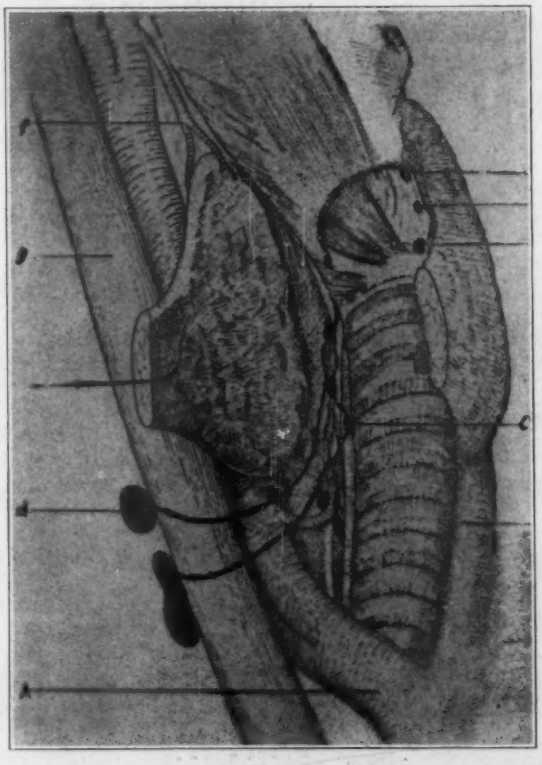

Fig. 6 (Case 3).—*C*, the recurrent chain of lymph nodes.

had had periodical attacks of dysphagia with severe pain in the chest. She had been troubled with an atrophic catarrh of the throat for many years. Finally pain, swelling and tenderness developed on the lower right side of the neck, with increased difficulty in swallowing. An incision was made along the inner border of the sternocleidomastoid muscle, and a large abscess cavity was found in the visceral space, with an opening near the right side of the esophagus through which the pus had entered the posterior mediastinum. The mediastinum was drained and the patient made a good recovery, the long-standing, brassy cough and the dysphagia disappearing entirely. The abscess in the neck started in the lymph nodes of the recurrent chain, and was in all probability due to infection from the throat (Fig. 6).

A few weeks ago, I saw the following case in consultation:

Case 4.—J. W. H., a man, aged 52, by accident swallowed a piece of wire from a defective egg beater. He complained of sharp pain in the upper esophagus on swallowing. The foreign body was demonstrated by a roentgenogram (Fig. 7), and the patient was operated on three days after the accident. An intrathoracic lobe of the left thyroid gland was removed and a piece of wire 4 cm. long was removed from the upper part of the esophagus. The wound was drained.

Fig. 7 (Case 4).—Piece of wire in the esophagus.

Eight days later, the temperature suddenly rose to 103 F., and the patient complained of pain in the left side of the chest.

At this juncture, I was called in consultation. The wound was immediately reopened, and an abscess was found in the retrovisceral space, extending down to a little below the level of the sternum (Fig. 8). The cavity was irrigated regularly with surgical solution of chlorinated soda and the patient made an uninterrupted recovery. The reaction of the tissues from the removal of the intrathoracic lobe of the thyroid and the subsequent drainage had probably partly obliterated the retrovisceral space, thus forming a temporary barrier

against the advance of the suppuration. The immediate interference prevented the breaking down of the barrier and the further extension into the posterior mediastinum.

Although four cases furnish rather small material on which to base the prognosis, I believe that the mortality rate in this type of acute

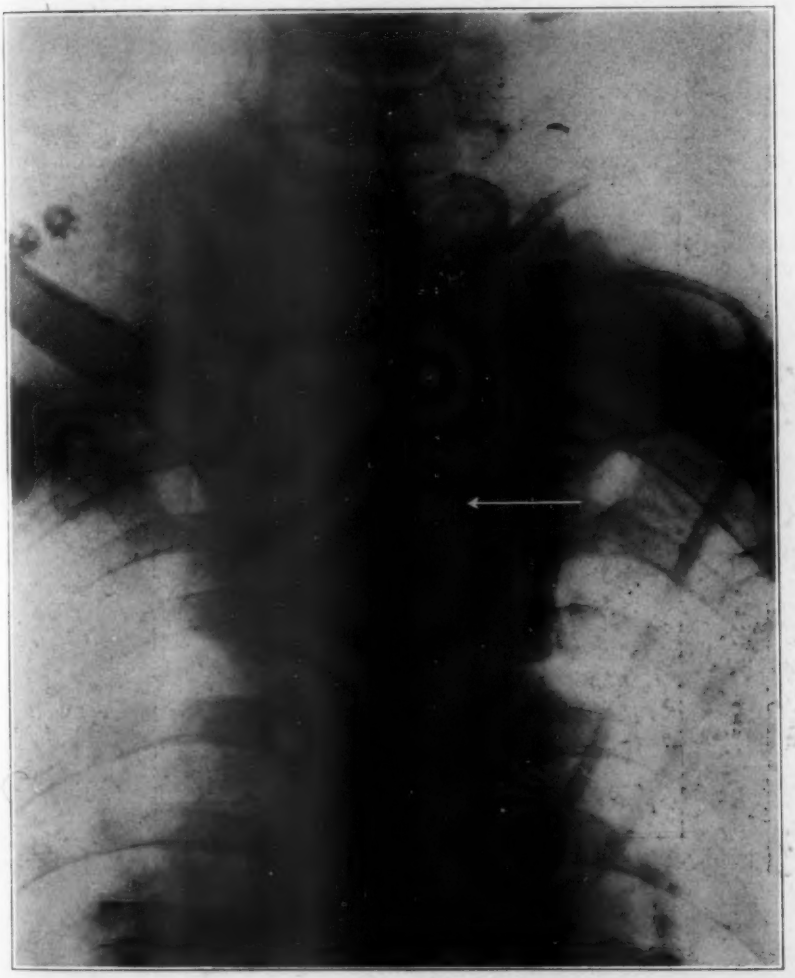

Fig. 8 (Case 4).—Appearance of the chest after insertion of rubber tube. The arrow points to the end of the rubber tube at the bottom of the abscess cavity.

mediastinal suppuration would not be great if early diagnosis were made and prompt surgical interference instituted. In Case 1, the suppuration had extended into the posterior mediastinum twelve days before we saw the case, and the secondary intracranial abscess causing protrusion of the right eye had undoubtedly formed before the operation.

The curious fact that a posterior mediastinal abscess may extend upward and come to the surface in the neck, has repeatedly been observed.

Case 5.—F. A. T., a man, aged 52, seen by me, Nov. 3, 1918, had had dysphagia since March, 1918. A stricture was found in the esophagus, 20 cm. from the

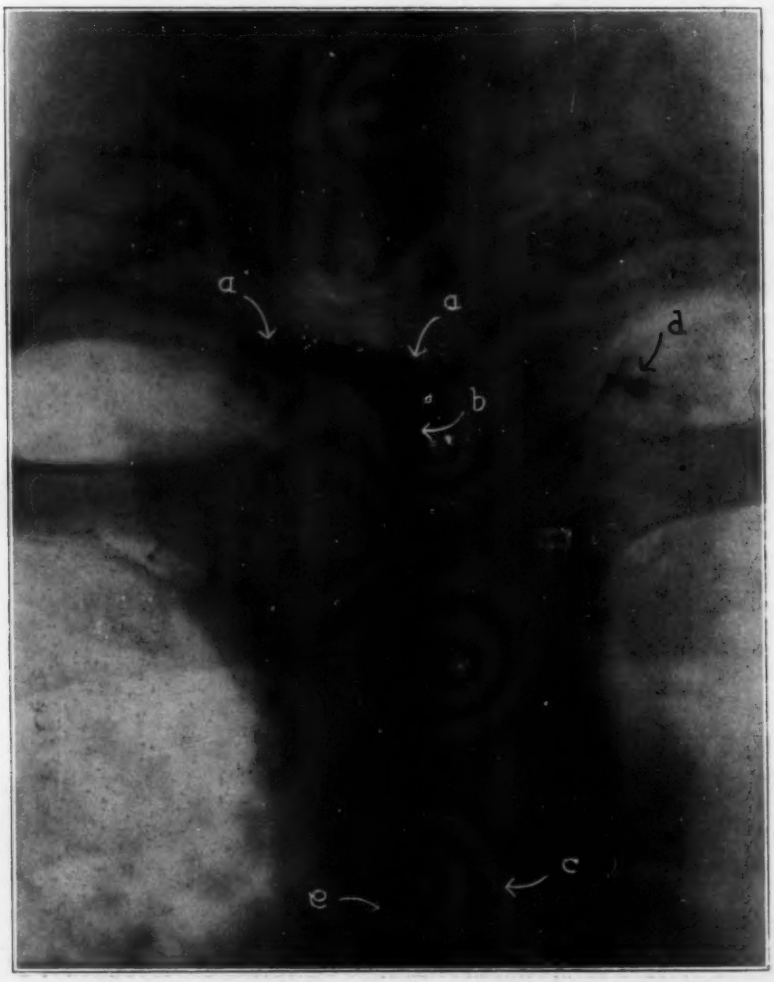

Fig. 9 (Case 5).—The complete fistulous tract between the esophagus, the trachea and the opening on the skin above the left clavicle: *a, a,* dilatation above stricture; *b,* stricture; *c,* communication with trachea; *d,* fistulous opening on the skin above the clavicle; *e,* esophagus.

incisor teeth. Bougies were introduced, but no further investigation was made, as I left the city for military service the following day.

I did not see the patient until one year later, in November, 1919, when he gave the following history: After an attack of influenza in February, 1919, he

had noticed occasional soreness along the front of the left sternocleidomastoid muscle from the level of the angle of the jaw to the suprasternal notch. About the middle of September, he noticed swelling and tenderness above the inner end of the left clavicle. This swelling had been incised, October 18, and a large quantity of pus released. Later, the patient noticed that food came out through the fistula. He had received regular bougie treatment and could eat

Fig. 10 (Case 6).—The mediastinal abscess cavity, showing bismuth (*a*); fistula on neck (*b*).

fairly well until September. From September until the abscess was opened, he had difficulty, but improved thereafter. He had considerable cough.

The fistula was injected with a bismuth mixture, and a connection between the esophagus, the trachea and the opening above the clavicle was demonstrated roentgenographically (Fig. 9). Esophagoscopy was repeatedly carried out in

order to determine the nature of the stricture, but the latter was unyielding and did no admit the smallest esophagoscope; so that, although carcinoma was suspected, it could not be demonstrated. March 29, 1921, a gastrostomy was performed.

The patient died in August, 1921, three and one half years after the onset of dysphagia. Necropsy revealed carcinoma.

Fig. 11 (Case 6).—Side view: Bismuth at bottom of the posterior mediastinum (*a*), and rubber tube in abscess cavity (*b*).

In one of the cadavers in which Schmitt had injected the retrovisceral space, he found that a narrow stream of the injected mass had followed the course of the inferior thyroid artery, which is partly in the retrovisceral space, to its origin on the thyroid axis. The latter vessel, given off from the upper and front part of the subclavicular artery,

lies behind the clavicular origin of the sternocleidomastoid muscle, and a little to the inner border of the scalenus anticus muscle. This corresponds to the fistulous opening in Case 5. The suppuration, advancing upward in the retrovisceral space, followed the course of the inferior thyroid artery.

I believe that the suppuration in this case started in the lymph nodes between the esophagus and the trachea, burrowed upward in the retrovisceral space, and somewhat later broke through the wall of the trachea near the left main bronchus and the wall of the esophagus.

CASE 6.—C. M., a boy, aged 11 years, whose mother and father were tuberculous, was admitted to the State Hospital for Crippled Children in March, 1915, with marked rigidity of the spine in the lumbar region and with prominence of the second lumbar vertebra. He was treated with the various appliances, and abscesses on the right thigh and buttock were at various times aspirated. Later, caries of the third dorsal vertebra was found, and an abscess on the left side of the neck was aspirated, and later incised. A fistula formed at this place and has remained open since. This fistula is situated behind the posterior border of the sternocleidomastoid muscle, somewhat below the level of the angle of the jaw. The boy had developed clubbed fingers. The sinus on the neck had been injected with a bismuth mixture and by a roentgenogram a posterior mediastinal abscess was demonstrated, extending to the diaphragm (Figs. 10 and 11).

I have just recently seen this patient in consultation, and examined him to determine what treatment could be given the mediastinal abscess. The abscess apparently originated in the third dorsal vertebra, broke through the prevertebral fascia and descended in the posterior mediastinum, later extending upward in the retrovisceral space.

In Cases 5 and 6, nature's way of draining suppuration in the posterior mediastinum is demonstrated. As far as cases of acute suppuration high in the mediastinum are concerned, I am firmly convinced that the majority can be cured by drainage through the incision described in this paper. It is easy to enter the posterior mediastinum in this way, and if the lateral wall of the esophagus is closely followed, the risk of injury to the pleura is small. In cases of chronic suppuration the drainage through the neck may not be sufficient, and in that case, should be supplemented by a posterior mediastinotomy. Thus, in Case 6, I propose to provide for proper drainage by entering the mediastinum through the posterior route.

DISCUSSION

DR. EMIL G. BECK, Chicago: I have observed a number of cases similar to two of those reported. A small fistula in the neck originating elsewhere may be mistaken for a broken down, suppurative gland. A case of this kind I had the opportunity to observe in the clinic of Professor Kocher, in Berne, Switzerland, in 1914. At that time, I was given the opportunity to demonstrate the injection of the fistula in his clinic, and a case of neck fistula was presented

for that purpose. I asked the assistant of Professor Kocher whether it was possible that the condition might be tuberculosis of one of the spinal vertebrae, and the assistant assured me it could not be. But one of the teachers insisted that the fistula should be injected, and stereoroentgenograms were made at once. These showed that the sinus led into one of the vertebrae of the neck. A second case, which I saw in Chicago several years ago, was of a similar nature, but more interesting. There was a fistula in the lumbar spine, and when it was injected through the lumbar spine, the bismuth paste came out through a second sinus in the neck, because there was a communication. I thought the eleventh dorsal vertebra was the seat of the trouble, but the fluid gravitated downward and spread upward, perforating in the neck. The communication showed distinctly, the mixture coming up through the neck. Such fistulas, when they occur here, may sometimes come from some source other than the neck itself.

Dr. Edward W. Archibald, Montreal: I should like to relate the history of a case briefly. A man in the twenties was taken with an acute illness, which was called influenza. It was accompanied by midline pain in the upper part of the chest, both front and back, which was not suggestive of pneumonia or pleurisy. About the third day of his illness, there developed a slight swelling in the neck apparently behind or in the thyroid. On about the sixth day from the onset, a dry, nonproductive irritating cough developed. The young man came into the clinic about the tenth day with a distinct swelling in the region of the thyroid, which was not painful and was not red. Before that time, the cough had become slightly productive in the sense that a frothy mucus was raised. There was a temperature of from 101 to 102 F., which had been present since the onset of the illness so far as we could ascertain. I saw the patient on Saturday afternoon with the physician to whose service he had been admitted. He had seen the patient on Friday, and had referred him to me, with the possible diagnosis of a subacute thyroiditis. Roentgen-ray examination had not been made. On examination, the condition was clearly not thyroiditis, but there was a swelling which threw the thyroid forward. That afternoon a roentgenogram was taken, and the next morning I called my colleagues on the medical and surgical staffs in consultation. In examining the patient and pointing out the swelling, I suddenly felt a sensation as of crepitation which had not been there before. There was clearly air in the cavity and by pressing on it a noise was elicited. The roentgenogram taken the day before revealed a dense shadow underneath the upper part of the sternum, occupying the midline and extending to the right side about 2 inches (5 cm.). The peculiar creptitant noise on palpation suggested the presence of both air and fluid in a cavity, and it seemed obvious that the diagnosis should be abscess of the mediastinum communicating with some air-containing organ, presumably the trachea. Encapsulated empyema was also to be considered. A roentgenogram taken one day later revealed the expected fluid level underneath the first or second rib, indicating air with pus. The patient was observed for a while. The fever continued. Within two or three days, he coughed up a mucopurulent sputum. Ultimately, he coughed up almost pure pus, and I considered it necessary, in view of the fever, to attempt to evacuate it. The stereoroentgenograms seemed to show it in the middle of the chest anteroposteriorly.

I decided, erroneously as it proved, on an anterior approach, and resected the right second rib in front. I came into a normal anterior mediastinum. I then opened the right pleura separately, and found it healthy. The idea of

the condition being a localized empyema was negatived by this finding. We concluded that a mediastinal abscess was present, of obscure etiology but originating in an influenza. I closed the opening and it healed promptly. Some days later, I went in above the clavicle, still anteriorly, it is true, but with the object of getting into the air cavity behind the thyroid, which, I hoped, might lead directly to the pus cavity. In spite of extensive dissection, I could find no air cavity, though the dissection was pushed down to the great vessels at the base of the heart, and well behind the thyroid gland. Probably, the air was mostly absorbed by this time. I then realized that I should have gone in posteriorly, if at all. The wound was closed. The man got well spontaneously, in spite of surgery. He "coughed up" his abscess; the air disappeared, and the last roentgenogram showed a diminishing shadow. After two weeks of normal temperature he was apparently well. The case demonstrated that a mediastinal abscess should be entered posteriorly. The condition was unquestionably not a localized empyema, as I proved by opening the pleura near it. The patient had had no signs indicative of pneumonia or pleurisy.

Dr. Carl A. Hedblom, Rochester, Minn.: Recently, I had a case of abscess in the posterior mediastinum in the case of a child with Pott's disease. She was emaciated, weak, cyanosed and very dyspneic. A roentgenogram revealed a shadow, which we interpreted as an abscess in the superior mediastinum, producing partial tracheal obstruction. The child was in a desperate condition, obviously unable to stand an operative procedure of any magnitude. To establish our diagnosis and if possible to relieve the dyspnea, I performed an exploratory aspiration with a long needle from behind in the second intercostal space, and obtained about 20 c.c. of pus. The dyspnea was promptly relieved. Culture of the pus remained sterile. We were obviously dealing with a cold abscess causing partial tracheal obstruction. Postural treatment for the tuberculous spine and further aspirations of the abscess were advised, but the child was taken home and died a few days later.

Dr. Willy Meyer, New York: Suppuration in the posterior mediastinum is of great surgical importance on account of sepsis. I recall the case of a woman in the forties who came under my care, twelve years ago, with sacculation of the esophagus due to cardiospasm. At the time, we did not know how best to deal with a case like this, but being more or less convinced that cardiospasm was due to some disease of the pneumogastrics, likely a persisting vagotonus, we exposed the esophagus by means of a free incision through the pleural cavity, loosened both pneumogastric nerves from the greatly distended tube and cut all the branches that ran from the nerves to the esophagus. Then we reduced the size of the pouch by a double plication, with the help of interrupted silk sutures. I was much interested in seeing this patient spontaneously regain the full power of swallowing. I could observe the same phenomenon in another patient similarly operated on later on. Personally, I believe that cardiospasm is due originally to a disease of the nerves. About a year later, the first mentioned patient was stricken by one of those influenzal pneumonias which were then prevalent in New York. Soon after, she developed a swelling over the region of the posterior mediastinum to the left of the spine, with the result that gradually a small fistula established itself, through which were discharged some of the contents of the esophagus, with pus. At that time, we did not inject the fistula with bismuth in order to find out the extent of the canal, as we feared it might aggravate the patient's condition. But the

fact that there was a discharge of food particles made it clear that we had to deal with an esophageal fistula and a localized subacute suppurating posterior mediastinitis. Unfortunately, the patient refused further operation. She had a continuous fever and succumbed after a few weeks. Here a posterior mediastinotomy was clearly indicated. The perforation was probably due to the cutting through of one of the silk sutures which enfolded the esophagus.

The question of acute posterior mediastinitis comes up in connection with esophagoscopy particularly, even in the hands of the most expert specialist, as a consequence to perforation. With the sudden onset of pain and fever accompanied by some difficulty in swallowing, soon after the examination, the patient becomes ill, and, as we know, such accidents, are usually fatal. In these cases, the indication is clear for the surgeon to perform a wide posterior mediastinotomy immediately, and to expose the infected loose periesophageal connective tissue and drain it by this route, thus affording an opportunity for some of these patients to recover, which would be utterly impossible otherwise. Of course, prognosis will depend on how soon the surgeon is called in.

In 1916, Dr. V. Gaudiani of New York published an interesting article on this subject in the *Annals of Surgery*. He had collected a number of cases of abscesses in the posterior mediastinum, and added two of his own. He emphasized the point that suppuration at and above the level of the third or fourth dorsal vertebra burrowed upward and should therefore be reached by the cervical route; whereas, suppuration at and below the level of the fourth dorsal vertebra usually burrows downward, below the arch of the aorta, and should be reached by the dorsal route. The reason is that the connective tissue of the posterior mediastinum at the neck is of loose structure, so that there is a tendency for the suppuration in the retropharyngeal and retroesophageal space to go upward and not downward. All these cases should be treated by aggressive surgery.

Permit me to mention a personal observation with reference to a suppuration situated somewhat higher than the posterior mediastinum, yet belonging to this class. Years ago, I treated a boy who had a retropharyngeal abscess in the upper portion of the cervical region. In the male, the best way to reach a retropharyngeal abscess certainly is not through the mouth, but from the neck, from without; just as we open a prostatic abscess best, not through the rectum but by way of the perineal route between the urethra and rectum. The incision of choice at the neck is posterior to the sternocleidomastoid muscle. In my case, I could feel distinctly the tender swelling behind the soft palate, from within the mouth. I first entered the normal space at the side and posteriorly to the esophagus, and by gently loosening the tissue upward, I finally entered a cavity filled with pus, which we drained to the outside. The boy made a good recovery.

I feel sure that, if the diagnosis of posterior mediastinitis is correctly and quickly established and operation promptly performed, we can save quite a number of these patients.

Dr. Howard Lilienthal, New York: As I understand it, the anterior mediastinum extends from the front to back of the chest. The superior mediastinum may therefore be drained either posteriorly or anteriorly. When drained posteriorly, it may be considered as the superior part of the posterior mediastinum, and the drainage may be continued downward into the true posterior mediastinum if necessary. After operative drainage of the superior mediastinum, the patient should be kept in a partly inverted posture, and the

drainage should be aided by frequent suction. In a case of superior suppurative mediastinitis from the retention of a fragment of high explosive shell, after another surgeon had failed to reach the fragment through an extensive incision in the neck, I was able at a second operation to locate the metal by means of a telephone probe, but could not reach it with my finger. Just as I was about to split the sternum, Major Yankauer, who was present, suggested that he might be able to extract the fragment by endoscopy through the wound. This was done, a piece of rough steel about the size of the phalanx of an adult finger being removed. Drainage was made by tube. The patient was inverted and suction was employed every fifteen minutes day and night for two days. The temperature, which had been as high as 104, at once dropped, and a perfect recovery resulted. In another case of suppuration following the removal of a retrosternal goiter, the patient was treated in the same way and recovered. The external part of the pleura which forms the wall of the mediastinal cavity is slow to granulate or to form adhesions, as much as two weeks being required to form a walled-off cavity. Before this happens fluid poured into the mediastinum with the patient erect or even semierect will find its way into other parts of the mediastinum. In posterior mediastinitis, drainage by posterior mediastinotomy may be performed, exposing the entire space and permitting one to pack it lightly with gauze for drainage. The surgery of the mediastinum is developing and will assuredly become standardized.

Dr. E. F. Butler, Sayre, Pa.: With reference to mediastinal abscess, I recall the case in the Walter Reed Hospital, that of an enlisted man in his early twenties. He had influenza in December, 1918, complicated by a posterior mediastinal abscess. Guided by the physical signs and roentgen ray, we reached this abscess through the second interspace posteriorly, on the left side, close to the angle of the rib. All we attempted at that time was simple drainage. Some time later, when his condition had improved, we desired to reach the bottom of the cavity, and we were able with the finger introduced through the original wound in the second interspace to reach the bottom of the cavity, and to establish secondary drainage at that point. Rapidly, after that, the cavity was reduced to a small sinus tract, and eventually it was obliterated. The boy had carried the abscess for some time before we were justified in attempting any surgical interference, on account of his extremely serious condition. Cultures showed *Staphylococcus aureus.*

Dr. William Lerche, St. Paul: The tendency of a posterior mediastinal abscess is to extend upward, which is the direction of least resistance. This has been observed in several cases. From these efforts of nature, incision and drainage through the neck seems logical, and the results have proved the correctness of this procedure in cases in which the suppuration is in the upper part of the mediastinum. In Case 2, the lower level of the abscess cavity was at the lower border of the eighth thoracic vertebra, which shows that, even at this depth, drainage through the neck may be sufficient. If, in an acute case, the posterior mediastinal suppuration extended from the neck to the diaphragm, I would drain it through the incision on the neck. If such drainage proves insufficient, it should be supplemented by a posterior mediastinotomy. In case of suppuration in the lower part of the posterior mediastinum, a posterior mediastinotomy is indicated. As regards the position of the patients after the operation, I keep them flat on their backs. In my first case, I put the patient in an exaggerated Trendelenburg position, but that is not necessary.

The outcome of Dr. Archibald's case was most fortunate. The spontaneous healing of an acute mediastinal abscess by breaking through the tracheal wall is a rare occurrence. Suppurating mediastinal lymph nodes not infrequently rupture into the trachea. I have seen several such cases and have one under observation now, in which there is a tracheo-esophageal fistula. These cases are usually of tuberculous origin.

VALUE OF THE LATERAL PROJECTION IN THE ROENTGEN-RAY EXAMINATION OF THE CHEST, WITH SPECIAL REFERENCE TO THE SURGICAL TREATMENT OF ABSCESS OF THE LUNG

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In order to emphasize the necessity and value of the exact lateral projection in roentgenologic examination of the chest, a group of cases have been collected, and are reported herein.

Several observers have emphasized the value of the oblique projection.[1] Valuable as this method has proved to be, the direct lateral projection, in our opinion, exceeds it. Up to the time of the use of the Potter-Bucky diaphragm, the direct lateral projection was not practicable in the majority of adults; but now, even in heavy individuals, good lateral roentgenograms can be obtained. The oblique projection, even if stereoscopic roentgenograms are made, cannot be interpreted so correctly as can lateral roentgenograms. However, at times, oblique projection is necessary, particularly in the study of foreign bodies in the respiratory tract or esophagus. This position is indispensable in searching for lesions of the esophagus, and in the examination of the heart, aorta and mediastinal lymph nodes.

But in the examination of the lungs for abscess, and more particularly in the localization of an abscess of the lung, the direct lateral position demonstrates the lesion and the operative approach with great accuracy. By the aid of opaque markers attached to the anterior, posterior and the lateral chest wall by means of adhesive plaster, and later by the marking of these regions on the skin with an indelible material, the line of approach to the abscess is made evident in the operating room. This method is of far greater value than stereoscopic exposures made in the anteroposterior position alone.

The value of this method is still further shown in the two-stage operation for abscess of the lung. At the first stage, if gauze impreg-

1. Evans, W. A.: Am. J. Roentgenol. **8**:106 (March) 1921.

nated with an opaque substance, such as iodoform, is packed into the wound, and anteroposterior and, particularly, lateral exposures are made, the surgeon can be informed with great accuracy of the intervening distance between the gauze packing and the abscess of the lung. This simplifies the second stage proceeding, and in many cases, provided the first localization has been approximately correct, permits the use of local anesthesia. If either the first localization or the first stage of the operation is not quite correct, any error can be corrected in the second stage, as the discrepancy will be obvious (Fig. 4).

In the localization of an encysted collection of pus between the lobes of the lung, or in the pleural cavity, lateral exposure is also of great value.

Also in rare and unusual lesions, such as congenital or acquired hernia of the diaphragm (Figs. 20 and 21), in thoracic stomach and in eventration of the diaphragm (Figs. 23 and 24), lateral projections are indispensable, particularly in determining the relationship of the abnormally displaced organs to the heart, and especially to the diaphragm (Figs. 21 and 24).

Furthermore, in the localization (Figs. 25 and 26) and removal of foreign bodies, such as bullets or shell fragments, the lateral roentgenographic exposure should never be omitted. One case has come under the observation of one of us (L. T. L.) in which a bullet wound in the front of the chest was unsuccessfully explored through a long incision in the front and side of the chest. After the wound had healed, the patient was referred for further roentgen-ray examination, and a lateral exposure disclosed the bullet close to the attachment of the eleventh rib to the spine. A small incision was made under local anesthesia, and the bullet was extracted in a few moments by Dr. W. A. Downes.

The following cases serve to illustrate the value of the lateral projection:

REPORT OF CASES

CASE 1.—*History.*—E. B., a man, single, aged 28, admitted to the surgical service of Division A, St. Luke's Hospital, as a patient of Dr. Green, March 28, 1923, gave the following history: Two and one half years previous to admission, he had pleurisy and pneumonia, after which he had a persistent cough, mostly at night and toward morning. He expectorated profusely, especially toward morning, a yellowish fluid, with a very bad odor at times. Three weeks previously, the patient noticed blood in the sputum, and he was thoroughly examined for tubercle bacilli, without any positive findings. He occasionally felt feverish in the afternoon and in the first part of the night. Perspiration was not excessive. The weight was maintained on an ordinary diet. There was no venereal history and no tuberculosis in his family. A hernia operation had been performed eight years previously, and another five years previously, with removal of the appendix through the hernia incision and a repair of a right hydrocele. The tonsils were small.

Physical Examination.—There was dulness at the right base posteriorly, anteriorly and in the right axilla, on examination of the thorax. Over this

area, there was a slight diminution in transmission of voice and breath sounds, and there were a few sibilant and moist râles. Scattered over both lungs were a few sibilant and sonorous sounds, but these were most marked over the right lung. Otherwise the physical examination was approximately normal. The extremities appeared normal except for clubbed fingers.

Roentgen-Ray Findings.—March 27, just previous to admission to the ward, the fluoroscopic and roentgenographic examination of the chest revealed an

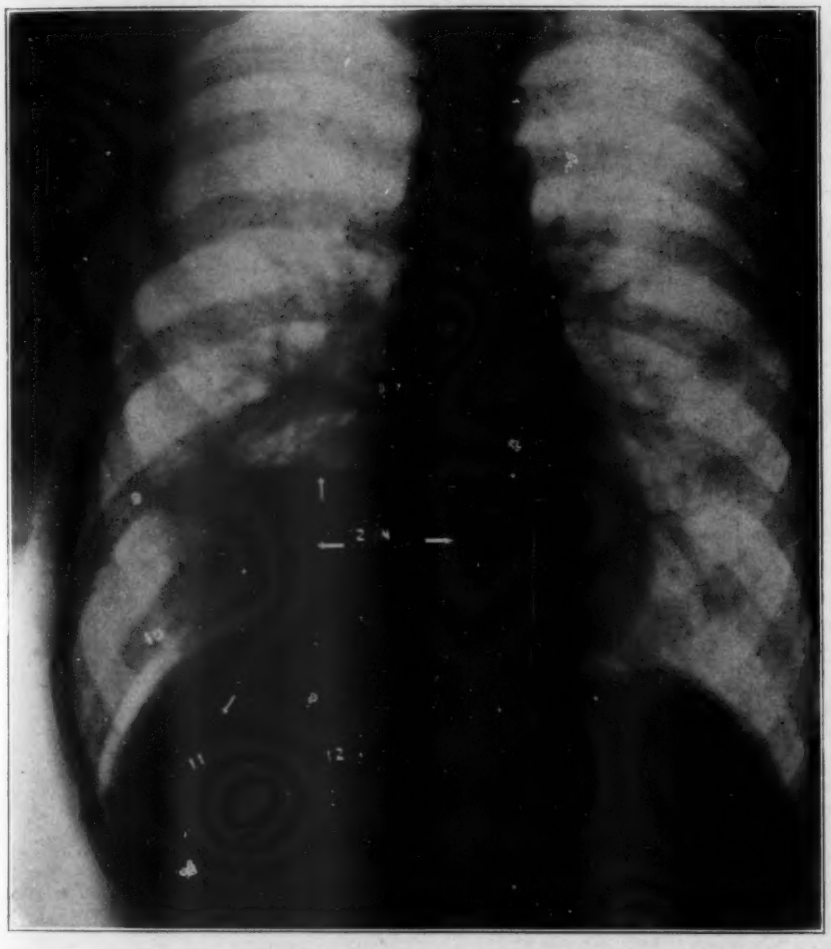

Fig. 1 (Case 1, E. B.).—Chronic abscess, right lower lobe, following pneumonia.

abscess cavity partially filled with fluid in the lower internal portion of the right lung. In the anteroposterior projection, the outer border of the cavity was about 1½ inches (3.7 cm.) from the chest wall. In the standing position, the cavity seemed to extend from the ninth to the eleventh ribs posteriorly (Fig. 1). With the patient in the dorsal position, the outer border of the cavity was about 2 inches (5 cm.) from the lateral chest wall. In the dorsal

roentgenogram, the midpoint of the abscess cavity was about 2 inches to the right of the median line in the region of the tenth rib posteriorly. Lateral exposure showed the abscess cavity to be well back in the lung (Fig. 2). This was also demonstrated clearly in a lateral exposure with the patient in the prone position (Fig. 3). The midportion of the cavity was in the region of the tenth rib in this position.

Operation.—March 29, under procain anesthesia, a portion of the tenth rib was resected. An incision was made down to the parietal pleura at this point, and it was found that the pleural surfaces were apparently not adherent.

Fig. 2 (Case 1).—Lateral projection, showing the posterior position of the abscess. The relative positions of the right and left sides of the diaphragm may be noted.

Accordingly, iodoform gauze was packed against the parietal pleura and a dry sterile dressing applied.

March 30, the roentgen-ray examination showed that there had been resection of a portion of the tenth right rib dorsally. In the upright position, the upper border of the gauze packing was on a level with the upper border of the abscess cavity (Fig. 4). In the lateral projection, the packing was directly over the upper portion of the abscess cavity. The fluid level was observed in both projections.

Fig. 3 (Case 1).—Prone position with lateral exposure showing the length of the abscess cavity in its vertical diameter.

Fig. 4 (Case 1).—One day after first stage. The gauze packing (*G*) above the unopened abscess over the upper portion of the cavity may be seen.

The second stage of the operation was performed, April 3. A little procain was injected into the lung tissue over the wall of the abscess, which was then opened. By inserting first the needle and then the grooved director and spreading them apart, the wall was opened and the finger introduced. A large quantity of pus tinged with blood gushed out. The abscess cavity, which was very large, was packed with two rolls of 1¼ inch (3.1 cm.) iodoform gauze packing.

Course.—April 4, fluoroscopic examination of the chest showed no fluid level. The gauze packing was thus evidently well within the cavity (Fig. 5).

April 7, the packing was removed from the abscess cavity. A blast of air through the wound showed a definite bronchial fistula.

April 17, the patient was discharged, improved, and was referred to the outpatient department. He coughed a little, but he did not expectorate and

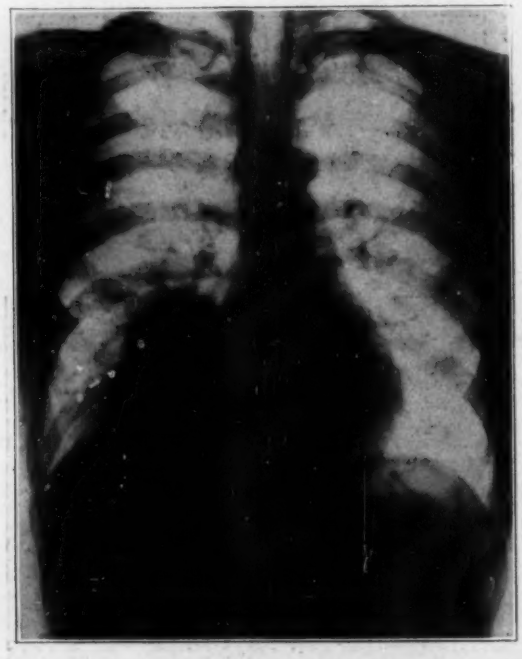

Fig. 5 (Case 1).—One day after the second stage (six days after the first stage). The gauze packing (*G*) is now in the abscess cavity and the fluid has been evacuated through the incision shown in Figure 6.

his breath was no longer foul. He felt much better and brighter since drainage of the abscess (Figs. 6 and 7).

CASE 2.—*History.*—S. S., man, married, aged 41, admitted to the surgical service of Division A, St. Luke's Hospital, as a patient of Dr. Green, Nov. 4, 1922, gave the following history: Three years previous to admission, he had an attack of influenza with pneumonia which confined him to his bed for three weeks. During the attack, he had considerable pain in the lateral aspect of the right chest. After recovery from the influenza, he had a chronic cough, which persisted up to the time of admission. At various times since the attack, he had coughed up small amounts of bloody sputum. This persisted up to the

Fig. 6 (Case 1).—The incision, posteriorly.

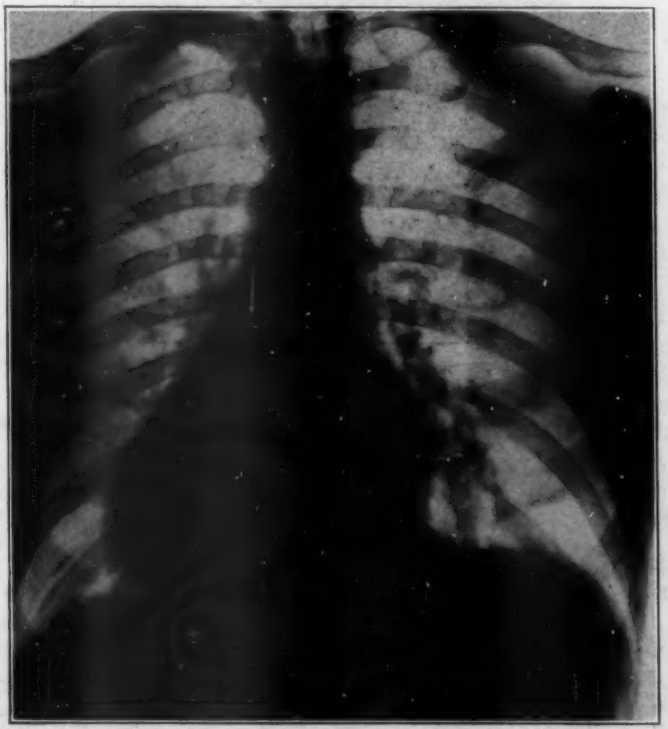

Fig. 7 (Case 1).—Abscess completely drained six weeks after second stage of the operation; posterior exposure (compare with Figure 1, anterior exposure).

time of admission. For the first two years after the influenza, he had no pain; but for the past year, he had had pain in the right side of the chest, off and on, of variable severity. Sometimes the pain was so severe that it kept him awake at night. Ever since the attack of influenza, he had felt weak and had been able to do only part of his work. He said he had lost about 20 pounds (9 kg.) during the past year. He had always had stomach trouble—"just a little indigestion." He stated that he had had a gastric ulcer four years before, and recovered without operation, at another hospital. No history of venereal disease was elicited.

Physical Examination.—The patient was a large and well-built white man without notable deformity. He had an anxious expression; coughed at intervals, an unproductive harsh spasm, and was apparently chronically ill. There was visible and palpable swelling of the cervical nodes above the clavicle on right

Fig. 8 (Case 2, S. S.).—Chronic abscess of the lung following pneumonia. The abscess cavity in the central portion of the right side and the indurated area at the right apex may be noted.

side. The glands were separate, quite soft, and freely movable. There was no similar involvement of the left side or other regions. Inspection of the teeth revealed pyorrhea. The tonsils were not hypertrophied. There was some edema of the soft parts of the right side of the neck, and venous engorgement. Expansion of the thorax was fair, the right side expansion less than the left. Examination of the lungs revealed dulness over the right apex, and hyperresonance elsewhere. The breath sounds were approximately normal in quality although diminished in intensity over the entire right side of the chest. No adventitious sounds were heard. There was marked clubbing of all the fingers, associated with watch crystal finger nails.

November 8 and December 8, examination for tubercle bacilli revealed no acid-fast bacilli.

November 7, a fluoroscopic examination of the chest revealed a shadow of increased density at the apex of the right lung which extended down as far as the lower border of the second rib anteriorly. In the central portion of this shadow was an area of lessened density measuring about 2 cm. in transverse diameter; but at no time was it possible to show a fluid level in this region. There was an irregular circular area on the right side over the third and fifth ribs anteriorly and the seventh and ninth ribs posteriorly, measuring about 7 cm. in transverse diameter and showing a fluid level which changed with the change in position of the patient (as demonstrated by fluoroscope and roentgenograms). A stereoscopic roentgenogram, with marker placed on the anterior and posterior wall of the chest, showed that the abscess of the lung was somewhat more posterior than anterior, and from its position would probably necessitate posterior exploration (Fig. 8).

Fig. 9 (Case 2).—Lateral projection; twelve days after second stage operation. The gauze packing (*G*) in the abscess cavity may be noted. The fluid has been evacuated through the incision shown in Figure 10.

November 8, in the stereoscopic lateral examination, the abscess cavity was posterior, lying directly over the shadows of the bodies of the vertebrae.

Operation (November 9).—First stage, thoracotomy: resection of the seventh and eighth ribs. Under procain anesthesia, a 5 inch (12.5 cm.) diagonal incision through the skin was made, overlying and in line with the eighth rib on the posterolateral aspect of the chest (Fig. 10). The incision was carried through the subcutaneous structures down to the periosteum of the eighth rib, which, after being infiltrated with procain, was divided and stripped from the rib for a distance of at least 4 inches (10 cm.). This portion of the rib was then resected. By retraction of the upper skin flap, the scapula angle being pulled upward, the seventh rib was exposed to a similar extent, 3½ inches (8.7 cm.) of it being removed. The intercostal artery was ligated at the upper

and lower angles of the wound, and the intervening intercostal muscle was cut away. The thickened parietal pleura alone remained at the base of the wound. The wound space was packed with iodoform gauze and the skin edges loosely held together with interrupted stitches of chromic gut.

November 10, a roentgen-ray report stated that there had been a resection of the seventh and eighth ribs in the axillary region. The upper portion of the dressing was about one half inch (1.3 cm.) below the lower border of the abscess cavity and was about on the same plane as regards the lung. Stereoscopic roentgenograms showed the position of the dressing in relationship to the cavity.

November 13, a stereoscopic posteroanterior exposure showed the upper border of the gauze packing to be about one half inch below the abscess cavity.

November 16, the second stage of the operation, evacuation and drainage, of the abscess cavity was performed. The iodoform packing was removed from the previous operative wound, and the pleura, which was exposed by the resection of the seventh and eighth ribs, was found to be tightly adherent to the lung tissue throughout the exposed area. With an aspirating needle, exploration of the lung tissue somewhat above and posterior to the cut end of the seventh rib was made, and the air-containing abscess cavity was entered. Blunt dissection along the line of this needle with a spreading instrument opened a tract to the cavity, permitting introduction of a finger and the escape of purulent and necrotic material. A strip of iodoform gauze soaked in liquid petrolatum was inserted through this tract into the abscess cavity and further plain packing was employed to fill the thoracotomy wound again.

On roentgen-ray examination, November 28, the gauze packing was in the midportion of the right side of the chest. There had apparently been resection of the seventh and eighth ribs. The right diaphragm line was high as compared with the left. There was still opacity at the apex of the right chest cavity. Lateral exposure showed the gauze evidently in the abscess cavity (Fig. 9).

November 29, all the iodoform packing was removed. The opening into the lung was about 2.5 cm. in diameter.

December 17, there was noted an opening of 1.5 cm., through which air issued on coughing. There was no odor and very little expectoration.

December 23, on discharge, the patient's general condition was excellent and the wound was granulating nicely. He had made a satisfactory convalescence, and had gained 7½ pounds (3.4 kg.). He was referred to the outpatient department for dressings.

Readmission.—He was readmitted, April 25, 1923, with the following history: Since discharge, four months previously, he had erysipelas of the face, and went to Mount Sinai Hospital where he was under the care of Dr. Lilienthal. He had some glands in the right side of the neck removed on account of suppuration. He had been suffering from cough and expectoration during the past three weeks. Gradually, he noticed that "his skin had become swollen." No urinary difficulties except slightly increased frequency were noted. He had pains in the chest, and vomited frequently. He had no chills or fever but perspired a great deal.

There was marked swelling of the hands, forearms and both ankles and feet. The wound in the right lateral posterior thorax was still open, with a rubber tube in place. There was a slight amount of thick, purulent discharge from the wound. The patient was placed on a salt-poor diet. He had no apparent renal insufficiency, and appeared to improve. He was again discharged to the outpatient department, May 4, improved (Fig. 11).

Fig. 10 (Case 2).—The incision on the posterolateral aspect of the chest.

Fig. 11 (Case 2).—Six months after operation. The abscess cavity is completely drained. There is still some induration at the apex (compare with Figure 8).

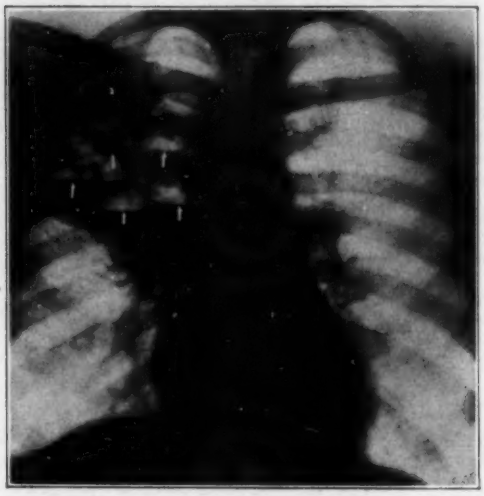

Fig. 12 (Case 3, F. C.).—Multiple abscesses of right upper lobe, of three months' duration. Five distinct fluid levels may be noted.

Fig. 13 (Case 3).—Patient in left lateral decubitus, roentgen-ray passing anteroposteriorly, confirming the five distinct cavities, indicated by different fluid levels.

CASE 3.—*History.*—F. C., man, married, aged 35, admitted to the surgical service of Division A, St. Luke's Hospital, as a patient of Dr. Green, March 15, 1923, gave the following history: Three months previous to admission, he caught cold, began to cough and brought up much pus with a terrific odor, which often nauseated him, although he never vomited. He had chills, fever and night sweats. At one time, he raised black "dirty looking" material which he thought might have been blood. He lost about 8 or 9 pounds (3.6 or 4.1 kg.) within five months. His chief complaint was cough with purulent expectoration for the past three months.

He had bronchitis nine years previously for about seven weeks. He raised no blood, and never had had pneumonia. There had been no tonsillectomy, no operations, no serious illnesses, no constitutional disorders. He had gonorrhea at the age of 22, but no chancre. Three examinations for tubercle bacilli (April 13 and 14 and May 2, 1923) were all negative.

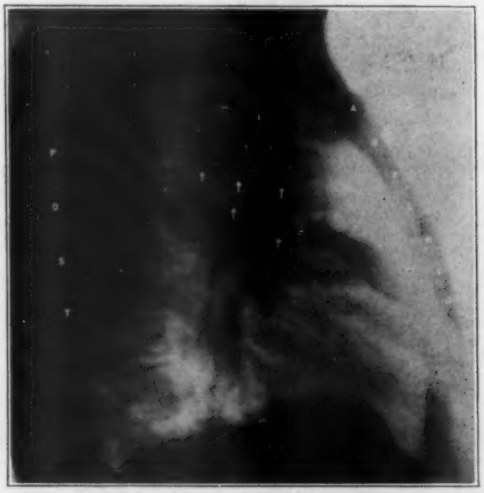

Fig. 14 (Case 3).—Lateral projection. The abscess cavities are approachable from the latero-anterior aspect of the chest, as shown in Figure 15.

Examination.—There was clubbing of the fingers and watch crystal finger nails (Fig. 16). The thorax expanded fairly well. The lungs were resonant throughout to percussion. Over both lungs, there were numerous scattered, sibilant and moist râles, most numerous at the right apex both in front and behind.

March 16, the fluoroscopic and roentgenographic examinations revealed a multiple abscess formation in the upper lobe of the right lung. There were at least five distinct cavities with fluid levels which changed with position of the patient (Figs. 12, 13 and 14).

Operation (March 21).—First stage, thoracotomy: resection of the second rib (Fig. 15). A transverse incision about 5 inches (12.5 cm.) in length was made over the second rib, starting at the right anterior axillary line and passing mesially toward the sternum. The subcutaneous tissues were divided and the pectoralis major and minor muscles were cut across in the direction

Fig. 15 (Case 3).—Incision in latero-anterior region.

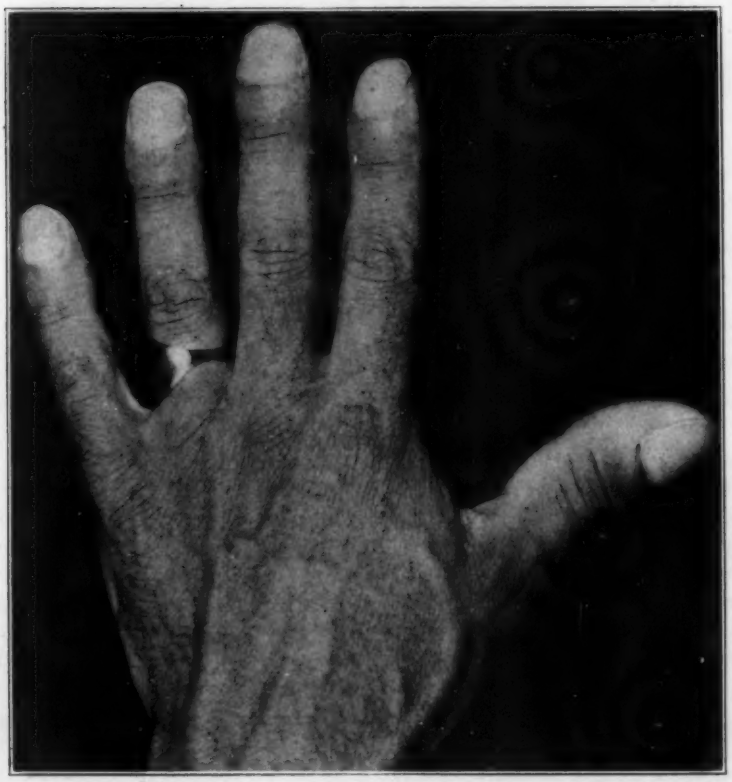

Fig. 16 (Case 3).—Clubbing of fingers and watch-crystal nails, characteristic in cases of lung abscess.

of the skin incision, the second rib being thus exposed. The periosteum of the rib was incised and a section of the rib about 3 inches (7.5 cm.) in length was resected. There were apparently no adhesions, and iodoform gauze was packed against the parietal pleura. The wound was left open and dry sterile dressing applied.

March 22, the roentgen-ray examination showed that the second rib had been resected in its anterior portion and the gauze packing appeared to be directly over the center of the involved area of the lung, as disclosed by the lateral and anteroposterior projections. It appeared logical to proceed with the second stage of the operation for drainage of the lung through this region just beneath the end of the gauze packing.

March 28, the second stage of the operation, drainage of the abscess cavity, was performed. The iodoform gauze packing was removed and an aspirating needle was inserted under local anesthesia. When the abscess cavity was entered, gas and pus were obtained. A groove director was then passed beside the needle into the abscess cavity, and the opening was enlarged, permitting the introduction of a finger. Five distinct separate pockets were entered by blunt dissection with the finger, and the opening in each cavity was stretched as much as possible. On withdrawal of the finger, a considerable amount of purulent material was forced out of the wound when the patient coughed. Iodoform gauze was then packed well into the central area.

Course.—March 29, the roentgenographic examination of the chest in the standard positions showed the gauze packing to be over the area of the multiple lung abscesses. In the lateral projection, one area with fluid level could be made out just posterior to the gauze packing.

May 17, the roentgen-ray examination showed the drainage tube apparently in the cavity, but there was fluid still present in the lower portion of one of the cavities. Further attempt at drainage should be instituted by means of operative procedure. The collection of pus appears to be posterior to the drainage tube and to the outer side of the area now drained.

CASE 4.[2]—D. N., woman, single, aged 28, admitted to the surgical service, Division A, as a patient of Dr. Green's, April 3, 1922, two weeks previous to admission had suffered from cough and expectoration, following a tonsillectomy, three weeks previously. At first, there was a sharp pain in the right axilla, which gradually became less, disappearing in about one week. The cough and expectoration of black tarry material, which the doctor said was what she "swallowed" at the operation, continued, especially at night and in the morning. The expectoration changed to a grayish green, with foul taste and odor, but no blood and no recurrence of the black material. The patient had no chills, but several night sweats. There was no history of tuberculosis in the family.

Roentgenographic examination, March 31 (medical service), revealed a shadow of increased density in the right chest extending, on the outer chest wall, from the first to the fourth rib. There was evidence of a fluid level which crossed at the second rib anteriorly (Fig. 17). Fluoroscopic examination revealed a change of fluid level with change in position of the patient, leading to a diagnosis of abscess of the lung with a cavity containing fluid.

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2. This case was presented before the New York Surgical Society, Nov. 8, 1922, and is cited here to illustrate the value of the direct lateral projection method of examination.

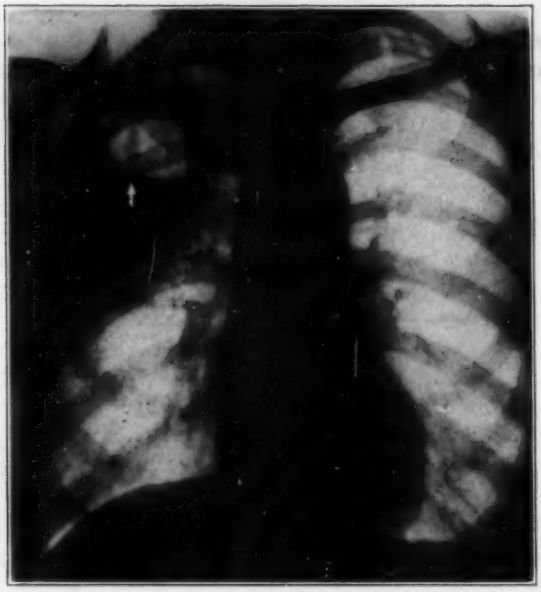

Fig. 17 (Case 4, D. N.).—Acute abscess three weeks after tonsillectomy with general anesthesia. The large abscess cavity in the right upper lobe necessitated operation, although of short duration.

Fig. 18 (Case 4).—Lateral projection, five days after second stage (two weeks after first stage). The gauze packing (*G*) and the complete evacuation of the abscess through an incision in the anterolateral region may be noted.

Operation (Dr. Green).—First stage, April 6: An incision 4 inches (10 cm.) long in front of the anterior axillary line and parallel to the second rib, was made. About 3 inches (7.5 cm.) of the second rib was resected, the pleura explored and the wound packed with iodoform gauze.

Second stage, April 15: The packing of the previous stage was removed and the wound repacked with iodoform gauze.

Course.—Roentgenographic examination a few days later disclosed a large shadow of opacity in the upper right chest, partially obscured by dressing (Fig. 18). April 26, when the second iodoform packing was removed, it was found that the abscess had opened.

Fig. 19 (Case 4).—Complete drainage of the abscess at the end of five weeks (compare with Figure 17).

The foul smelling discharge gradually diminished, and the patient was discharged, May 7. Figure 19 is a roentgenogram made May 23, five weeks after second stage. The wound was practically healed, June 1.

CASE 5.—*History.*—J. M., man, single, aged 30, referred for roentgen-ray examination by Dr. W. A. Downes, since childhood had had a "peculiar" sensation in his chest. Several physicians diagnosed the condition as dextrocardia. In spite of being told his heart was out of the normal position, he engaged in very active athletics, winning, among other contests, several long distance races.

Roentgen-Ray Examination.—This disclosed the fact that the heart was more to the right than normal and that there was some opacity in the lower portion of the left chest. Without study by means of an opaque meal, this might have been regarded as due to a thickened pleura with fibrosis of the lung. A few moments after the administration of an opaque meal, food appeared

in the chest cavity, indicating that the jejunum was in this region. Later exposures showed that the entire small intestine and the colon, except for the descending portion and the sigmoid flexure, were in the chest cavity (Figs. 20 and 21). Lateral exposures showed a complete absence of the left side of the diaphragm (Fig. 21). This is particularly striking when compared with a lateral exposure of a normal diaphragm, in which case there are two distinct shadows, the dome of the right diaphragm being several centimeters above the left (Fig. 22).

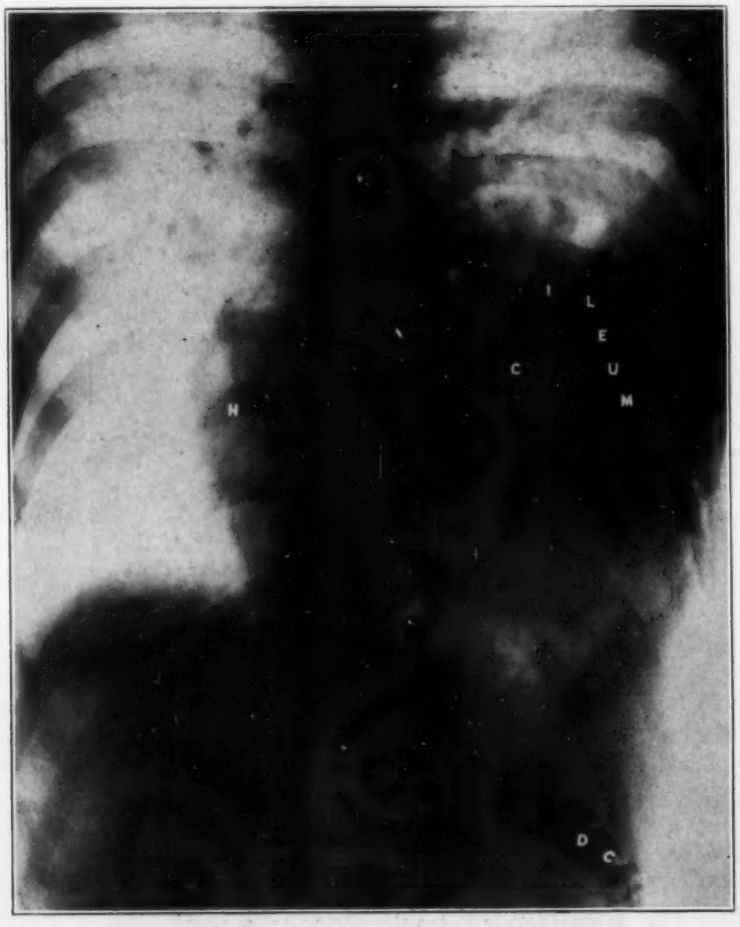

Fig. 20 (Case 5, J. M.).—Right border of the heart displaced to the right. Absence of the diaphragm shadow on the left side and the presence of the small intestine up as far as the upper border of the heart may be noted.

Comment.—This case is of extreme interest because of the congenital nature of the abnormality, together with the absence of the left side of the diaphragm. In view of this absence of the diaphragm as demonstrated in the lateral exposure (Fig. 21), operation would not appear to be advisable, especially as the patient's symptoms are not urgent. While such a condition is ordinarily

Fig. 21 (Case 5).—The value of the lateral exposure showing absence of left side of diaphragm is evident when compared with the normal diaphragm (compare Figure 22).

Fig. 22 (Case 1).—The two distinct shadows of the right and left sides of the diaphragm may be noted (compare with Figure 21).

Fig. 23 (Case 6, C. F.).—Eventration of the diaphragm simulating partial hernia of the diaphragm but proved by lateral exposure to be an eventration (compare Figure 24).

Fig. 24 (Case 6).—Lateral exposure of eventration of the diaphragm. The distinct shadow of the high left side of the diaphragm while the right diaphragm remains in normal position below may be noted (compare with Figure 22, normal). The peculiar shape of the stomach conforms to the high diaphragm.

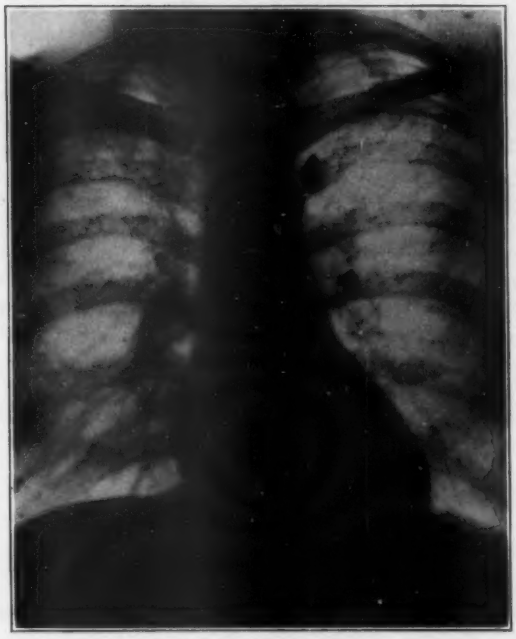

Fig. 25 (Case 7, H. G.).—Bullet lodged in chest for five years (for depth of projectile, compare Figure 26).

Fig. 26 (Case 7).—Base of bullet almost resting on arch of the aorta.

regarded as a handicap, up to the present time it has not proved to be such in this case. As previously mentioned, this patient has on numerous occasions participated in athletic events.

Case 6.—C. F., man, married, aged 38, referred by Dr. W. A. Bastedo, for five years complained of pain in the epigastrium, nausea, vomiting and distress in the region of the heart. The patient had been informed from previous roentgen-ray and fluoroscopic examinations that he had a hernia of the diaphragm.

Roentgen-ray examination showed the heart distinctly displaced to the right (Fig. 23). The diaphragm on the left side showed a high degree of eventration. On administration of an opaque meal, the stomach had a peculiar appearance, due to the cardiac end passing unusually high on account of the eventration of the diaphragm. Lateral exposure showed the stomach to be inverted, practically in the shape of a question mark. The diaphragm, however, could be distinctly outlined above the highest point of the stomach, proving the case to be one of eventration and not hernia (Fig. 24). Hyperperistalsis, due to the presence of a duodenal ulcer (confirmed later by operation by Dr. W. A. Downes), caused constriction of the stomach (Fig. 23) in such a way as to simulate hernia of the diaphragm, in which only a part of the stomach is above the diaphragm.

Case 7.—G. A., man, single, aged 28, referred from the U. S. Veterans' Bureau, five years previously was struck by a bullet, which entered under the angle of the left scapula. He coughed up blood and felt pain about the heart, but did not lose consciousness. At the present time, he complained of cough and some difficulty in breathing on exertion.

Roentgen-ray examination showed the pointed projectile on the left side on a level with the first costal cartilage (Fig. 25). Lateral exposure disclosed the fact that the projectile was situated deeply in the chest, almost resting on the arch of the aorta (Fig. 26). Fluoroscopy showed that the bullet moved with each pulsation of the aorta.

CONCLUSION

Exact lateral roentgenographic examination is essential in the localization of lesions of the chest.

DISCUSSION

Dr. T. C. Davison, Atlanta, Ga.: As to the value of lateral roentgenograms in examination of the chest, especially in cases of abscess, it is just as important to have these pictures as it is to get a lateral view of a fractured bone. As Dr. Green has pointed out, you cannot locate a missile by securing an anteroposterior view unless you have a lateral view also. The same thing holds true of abscess of the lung; I have had two cases in which the abscess was easily demonstrated. Unless you have a lateral view, you do not know whether to search for the abscess in the anterior or posterior part of the lung.

Dr. George J. Heuer, Cincinnati: I have had no experience with the direct lateral roentgen ray. We have been making use of the oblique roentgen ray, and I shall encourage our roentgenologist to do some of this work. I would appreciate it if Dr. Green or some one else would tell us whether there is any special technic connected with these lateral roentgenograms.

I have never made use of the preliminary packing of gauze in order to promote adhesions between the visceral and the parietal pleura. From my own

experience, it is a question whether that is necessary. Whether or not the procedure I have used is any better, I do not know. Stripping the parietal pleura is such an easy procedure that I use it in practically all cases, not only in handling lung abscess but in approaching other intrapulmonary conditions. If one will mobilize the lung and parietal pleura, and see that they are brought in close contact, one can introduce a series of sutures which will insure adhesions without the packing of gauze, and perhaps more surely than will the use of gauze.

We rarely make use of the cautery. We have usually entered a lung abscess by blunt dissection without the cautery.

An interesting thing is the treatment of chronic cases. Of course, that does not come within the province of this paper really, but acute abscesses are cured in a large proportion of cases. I think that in twenty-four acute abscesses we have had, eighteen patients have been absolutely well for a period of from one to ten years; while three are not entirely well; that is to say, they still have slight cough and expectoration. But our experience has not been anything like that in the treatment of chronic lung abscess. In a series of ten cases, I think, of chronic lung abscess, we have failed to cure more than 50 per cent.; and in the lung abscess which Dr. Green showed last, I was interested more in hearing what the late result was than in the method of approach, because, after all, the method of approach is pretty satisfactory.

Dr. W. S. Lemon, Rochester, Minn.: The consideration of localization of abscess in the lung should be studied from the clinical as well as from the roentgenologic standpoint. It is true that the roentgenogram gives a definite location of an abscess, and, as has been shown, assurance is increased by the methods that have just been described. It is, however, only one method of inspection, particularly useful because it increases many fold the accuracy of one's senses.

A method which has not been spoken of in this meeting is worthy of attention, namely, the location of the abscess with the point of the finger and the cooperation of the patient in limiting the points of tenderness. It is quite well known that the parietal pleura alone is sensible to pain. The location of pleural pain is variable, however, and depends on two factors. It may be the evidence of peripheral neuritis and adjacent to the pleural lesion; or it may be referred pain and distant from the area involved. Those lesions affecting the posterior portion of the pleura, and again the pleura covering the diaphragm, produce referred pain, represented superficially by the distribution of the seventh to the twelfth dorsal segmentations, and the distribution of the phrenic nerve. Not infrequently, the localization is difficult when the usual methods of examination are employed. In some instances, the sounds cannot be heard with the ear, but it is often possible by placing a finger in the interspace and using moderate pressure to determine accurately the location of the abscess and to decide whether the lesion is in the anterior or the posterior location. Even in using the roentgen-ray, studying either a flat plate or a stereoscopic plate, confusion may arise; and the method outlined becomes of value in the localization of the abscess and its type and its depth. In any instance, the clinical findings should be correlated with those of the roentgen-ray and one cannot doubt that there is decided advantage in using not only the anteroposterior but also the lateral position for localization.

Dr. Howard Lilienthal, New York: Roentgen-ray examination may be misleading as to the proper site of operation if we depend entirely on roentgen-

ologic appearances. For example: An abscess in one part of the chest close to the surface may change its location as soon as the pleura is entered. Even light adhesions, perhaps demonstrated roentgenologically, break down and permit the focus to pull away. In cases of this kind, differential pressure is of value in bringing the lung to the surface so that means may be taken to cause adhesions there. A small preoperative induced pneumothorax will be a great aid in determining the location of the abscess and its fixation. Unless there is reason to believe that the abscess is firmly adherent to a known area on the parietal pleura, it is better to make a wide intercostal incision for exploration and, after finding the abscess, to resect ribs over it, deferring drainage for another stage, six or even eight days later. This wide thoracotomy with the application of the rib spreader is not dangerous nor liable to cause shock in itself, and it gives the great surgical advantage of a true exploration. Dr. Lemon's attitude in regard to the value of clinical signs in addition to the roentgen ray is most commendable. It must be remembered that pain in the diaphragm is reflected through the phrenic nerve to the shoulder and rarely if ever is experienced in the neighborhood of the muscle itself. Certain authorities have even concluded that the part of the diaphragm which is irritated may be determined by the exact location on the shoulder in which the pain is felt.

The straight lateral roentgenogram is particularly valuable in sacculated empyema. It has often saved me from unwittingly entering the free pleural cavity.

Dr. Willy Meyer, New York: At the Lenox Hill Hospital, we too found it of great advantage in the diagnosis and localization of pulmonary abscess to take the roentgenogram by lateral exposure also. From the standpoint of the surgeon, it is of greatest advantage to know beforehand the exact location of the abscess; also, whether the diseased lung is attached to the chest wall. In exceptional cases only is the lung nonadherent. Lately, at our hospital, in the case of a child who had had suppuration for years, there were no adhesions whatever found when the pleural cavity was entered. In subacute and chronic cases, we will do best in such an emergency to select the two-stage method and first suture the lung to the chest wall.

I feel sure that in the course of time our roentgenologists will help us a great deal in refining the diagnosis by the lateral exposure as well as by such other methods as they will yet develop, showing us on the plates where adhesions will probably be found. After all, for the patient the one-stage operation, based on such refined diagnosis, has many advantages. It is best performed under regional and local anesthesia.

In one case that comes under the classification of Dr. Green, I thought that, according to the roentgen rays, by going in laterally I would probably find the lung adherent and reach the abscess easily. But I dropped into the free pleural cavity. The patient, an Italian, was highly nervous; so I decided to make the operation one-stage. I introduced my hand and found the lung adherent posteriorly, near the spinal column. Under the guidance of the hand within the chest I then aspirated, inserting the needle at the place of adhesion, and made the assistant pull on the piston. We found pus. The free pleural space, which meant in this instance almost the entire pleural cavity, was then drained airtight, and the chest wound was closed. At the same operation, resection of a few ribs with excision of the intercostal tissues was added, posteriorly, where

adhesions had been found, and the lung was incised parallel to the spine, and the abscess successfully opened. It was drained posteriorly, while that portion of the pleura which was first opened was drained at the side in the airtight fashion. The patient recovered.

In favorable cases, we can help ourselves in this way and avoid a two-stage operation. As mentioned before, our efforts in this direction will be greatly assisted by further efforts of the roentgenologists.

Dr. Adrian V. S. Lambert, New York: We have had some experience with the lateral roentgen ray and have been somewhat confused in interpreting the plates, not having had the advantage of such excellent ones as Dr. Green has shown. The difficulty we have had has been, first, to obtain a direct lateral view and, second, correctly to orient the focus of disease when some slight obliquity of the plate is present. Another difficulty in obtaining plates has been to eliminate sufficiently the shadow of the heart so as not to confuse the picture, particularly in cases of suppuration in the left side of the chest. In a number of cases, we have been unable to interpret these lateral roentgen rays, especially in lesions in the upper lobe. We have been unable to obtain in the upper lobe any lateral roentgenogram which definitely depicted the abscess as anterior or posterior. I think it has been largely on account of the lack of good technic which Dr. Le Wald has developed. It would be instructive if Dr. Le Wald would give us a few details as to how he proceeds. We have rather abandoned the lateral picture, for the fluoroscope. By marking on the chest, from the fluoroscopic examination in various positions, the site of the shadow, we have been able to locate the suppurative focus.

Dr. Emil G. Beck, Chicago: I should like to ask Dr. Le Wald a question which I think is of practical value to us. In taking stereoroentgenograms of the chest, I understand that Dr. Le Wald takes two pictures anteroposteriorly and two laterally—in other words, four exposures. We use the Potter-Bucky diaphragm, and would not the amount of exposure be too much for the patient at one time?

Dr. Carl A. Hedblom, Rochester, Minn. No one has mentioned the necessity for a roentgenogram in the oblique position to demonstrate a lesion at the base of the lung on the left behind the heart. The shadow produced by such a lesion is always masked by the heart shadow if the plate is taken in the usual anteroposterior position. We have observed several such cases, in some of which the lesion was demonstrated only after it had extended laterally beyond the left border of the heart. Foreign bodies also may be missed in plates taken in the usual way. In one case in my experience, a silver collar button present ten years was missed in the anteroposterior plate, but was clearly demonstrated in the plate taken obliquely. The dome of the liver may similarly mask a lesion or foreign body.

Dr. Leon T. Le Wald, New York: The question brought out by Dr. Beck is a good one. We did take stereoscopic exposures. We used in addition anterior stereoscopic exposures. As has been said, we get valuable information in this way. The oblique roentgenogram is valuable at times in locating some foreign body in the region of the bifurcation of the trachea or in locating a gland at the bifurcation which may be involved. We do not disparage the use of the oblique projection at all. It is, however, exceedingly difficult to use as a localizing measure. As Dr. Lilienthal has said, it is almost impossible to utilize the oblique projection for this purpose. A bullet right under the edge of the sternum anteriorly can be seen from in front and from the side. You

know it is in the median line. You cannot very well make a mistake when you have a lateral roentgenogram. In the case of a calcified gland, if you can utilize the esophagus or trachea as a localizing landmark, you can, by giving the patient an opaque substance, demonstrate the position of the gland. It can be shown laterally on the same plane with the esophagus or slightly anterior to it. This brings up the question that Dr. Lilienthal and Dr. Meyer referred to; that is, localized, encysted, multiple sacculations of fluid in the pleural cavity. One is safe in making a puncture in a case like this. The fact that there were adhesions was shown better in a second roentgenogram.

Taking an oblique exposure, tilting the patient, you see different fluid levels. That will tell you where the pleura is adherent. Would it not be justifiable at times to introduce a little air? for if you can locate the adherent portion and localize that place, it would give you a clue where to go in. There may be spontaneous rupture of the abscess, and after this a spontaneous pneumothorax, giving you a clear cut picture of the area which was adherent; but it may then be too late for a radical operation.

With a lateral view, we are able to see a high esophageal lesion, a retropharyngeal abscess or a mediastinal tumor. This paper included the elaboration of other lesions of the chest.

A slide showing a mediastinal tumor with high lateral exposure, presents the area exactly as it appears and gives a localization of the posterior extent of the lesion. In operating in a case of this sort, with a direct lateral view, one has a clue as to where to enter and what technic to follow. You may be told by the roentgenologist who uses the small type of apparatus that was brought out during the war, and the radiator tube, for the purpose of having a simple apparatus, that lateral exposures are impossible. This is because the apparatus gives a voltage of only a 5 inch gap. When the Potter-Bucky diaphragm, which originated in Chicago, came out, we asked Professor Coolidge if it would not be possible to use a much higher voltage than we do now. By cutting out secondary rays, we found we could use a higher voltage than we had heretofore, and we now use a voltage as high as a 7½ inch gap. You can thus get penetration by the rays in the same length of time and get away from the secondary radiation by means of the Potter-Bucky diaphragm.

For foreign bodies, which are well shown by lateral exposure, it gives a method of localization which could not be obtained by the oblique position. A New York bronchoscopist asked me if I would see a case of foreign body with him. It was thought the child had a needle in the lower lobe of the right lung. They had only taken anteroposterior exposures. We took a lateral exposure and found the needle was located in the muscles in the back of the chest wall and not in a bronchus. The child had been coughing for several months, and the presence of a foreign body led to the assumption that it was in a bronchus. In this case, bronchoscopy was to have been carried out because of the erroneous impression gained from anteroposterior exposures. It is a simple thing to suggest lateral exposures, but it has been neglected in the past.

In a case for diagnosis of a possible lesion, there was a marked increase in the shadow about the heart area. The records showed it could not very well be a pericardial effusion, and yet some insisted that a pericardial effusion ought to be considered. Another roentgenogram showed the appearance sometime later. There was a question wherether there was a solid mediastinal tumor connected with the pericardium, or a dermoid present. A lateral view showed bulging posteriorly. An oblique view did not help much in interpreting this particular case, but a straight lateral view showed projection posteriorly.

In a case seen three months ago by Dr. Lilienthal, the man had a history of slight distress in the chest. In the anteroposterior views, the only shadow of the diaphragm was that of the right dome. On lateral exposure, there was an absence of the shadow of the left side of the diaphragm. This was undoubtedly a case of congenital absence of the left side of the diaphragm. The entire colon, cecum, appendix, ileum and jejunum were all above the level of the right side of the diaphragm, so that in the true abdominal cavity there was nothing but the descending colon, the stomach and a little of the duodenum, which then passed up into the chest cavity. At no time could one make out a separate shadow of any portion of the *left* side of the diaphragm.

The question of voltage I think has been answered, and the question of pressure on the esophagus and trachea has been referred to.

Dr. Willy Meyer, New York: We know that, with the help of the pneumoperitoneum, adhesions of organs within the abdominal cavity are found and are seen on the plate. The question arises: Can the same thing be accomplished in the thorax? Can some gas be injected into the pleural cavity that will show on the plate where the lung is adherent. We know that air, nitrogen and oxygen cannot do it. Perhaps another gas or a mixture of gases can be found to accomplish it. Such special kind of artificial pneumothorax might give us the desired details, guide the surgeon in his operation and save him and the patient much trouble.

Dr. Leon T. Le Wald, New York: Usually, the use of air or some gas of about that density is sufficient, I believe, because, owing to the large collapse, a lung that is compressed casts a denser contrasting shadow, and the adhesions themselves would easily contrast with the air.

Dr. Meyer's question is a very interesting one because a little work has been done on the use of gases of different intensity. I tried it out experimentally with the late Dr. E. K. Dunham. It is not an easy procedure, and it is not quite as productive of advantage as one might think, although theoretically it is the proper thing, and perhaps in the near future we will do it.

A Member: I should like to ask whether the pneumoperitoneum is used to demonstrate the presence or absence of the diaphragm?

Dr. Lilienthal: In diaphragmatic hernia, the induction of pneumoperitoneum previous to roentgen-ray examination is of the greatest value because it permits the diaphragm to be seen in profile. The procedure when properly carried out is devoid of danger. The presence or absence of a hernial sac may be demonstrated.

Dr. Le Wald: As regards the production of pneumoperitoneum in the diagnosis of congenital hernia of the diaphragm, cases have been reported in which there was no separate sac. I could not demonstrate a limiting membrane in my case, and if we introduce air and get collapse of the lung, it would not be desirable, although it might be valuable in determining whether there was a diaphragm or not. As congenital absence of the diaphragm has been reported at necropsy, we might regard it as probably proved if we cannot see it in the roentgenogram. I shall be glad to have any information on that point from any of the members.

Dr. Lilienthal: You would not only see whether you had a diaphragm or not, but you could see whether the true hernia was prolapsed. If you had a hernia with a sac, the air would demonstrate the presence of the sac.

Dr. Nathan W. Green, New York: In answer to the query as to what special method or methods we employ, Dr. Le Wald has answered that techni-

cally. I should like to add that the special method that has been used is the cooperation between the roentgen-ray department and the surgical department. Dr. Le Wald has cooperated in every way possible whenever it was feasible, and we have tried to do the same for him. That helps a great deal.

Dr. Meyer speaks of a two-stage operation as unneccesary in some cases. I think it is, but I think also that the second stage of an operation is rather slight in most cases. I have not had much luck with suturing the visceral to the parietal pleura. One gets air in, and it does not go very well. I would rather follow this method of packing down on the parietal pleura, and in a week's time opening through it.

Dr. Meyer mentioned cases of acute abscesses in which the patient recovered after operation and drainage; and sometimes they get well without operation and without drainage. We like to put off operating for quite a little time, to determine whether the patients are going to get well without operation. The fourth patient in our series has been completely well and has been married a year. There has been no recurrence of the trouble.

Dr. Lemon spoke of locating a lung abscess by means of the finger. This is intensely interesting. Although the finer points in diagnosis which show a man to be a clever diagnostician rather than a clever technician should be cultivated, I do not think we should use one method of technic to the exclusion of other methods, but in a large service we have to use that method of diagnosis which lends itself most readily to the time we have at our disposal.

Dr. Lilienthal spoke of attenuated adhesions being present. I can bear him out in that remark because I have found adhesions that were attenuated in more cases than one, and for that reason I have adopted the two-stage operation—packing and opening later.

I am glad that Dr. Meyer has given support to the lateral method by using it in the Lenox Hill Hospital. The one-stage operation is ideal, and one does not like to subject a patient to more than a one-stage operation if he can help it. However, the second stage is a slight procedure, it being the terminal procedure of the first stage, a week later. As a rule, these patients do not need to have an anesthetic and the second stage of the operation really does not amount to much more than a dressing. One must use judgment in each individual case.

As to Dr. Lambert's remarks, I would say that it will take a great deal of effort to get the lateral exposure properly; it requires a great deal of pains, and when the service is crowded, I do not think the roentgenologist can give the time necessary for cooperation.

OPERATION FOR ACUTE EMPYEMA ON PHYSIOLOGIC LINES

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The observations reported in this paper are based upon cases at the Lenox Hill Hospital on the service of Dr. Willy Meyer, under whose guidance and assistance the method has been worked out.

Empyema, or more correctly acute suppurative pleurisy, offers a wide latitude in choice of operative procedure. As Robinson [1] aptly states: "The literature on this subject abounds in reports of small groups of cases with uninterrupted recoveries of short duration, treated with or without methods of drainage or suction, and the recovery of such cases should be credited to their early recognition more than to the method of handling."

The three standard types of operation usually employed are: (1) aspiration by needle puncture; (2) the open method, either with or without resection of rib, and (3) the closed method, popularized in this country by Kenyon,[2] although used first by Bülau [3] in Germany in 1891.

All of these methods are good in suitable cases, but all leave something to be desired.

Aspiration at best gives but temporary relief and, in my experience, has never cured.

The open method works satisfactorily with most of the patients that are going to get well and is usually the method of choice. Its greatest drawback is the open pneumothorax it produces, which continues; while its greatest advantage (in rib resection) is the thorough evacuation and cleansing it allows.

The closed method approaches nearer the ideal, physiologically, but falls short in the evacuation of the large masses of fibrin and in one's inability to explore the pleural cavity.

Is there not some method which combines both the open and the closed, and has all their advantages? We believe that we have found such a method, which is here presented.

We had noticed, in several cases in which a large incision was made and rib resection performed, with introduction of a drainage

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1. Robinson: Boston M. & S. J., October, 1910.

2. Kenyon, J. H.: Preliminary Report of Method of Treatment of Empyema in Children, Med. Rec., October, 1911, p. 816.

3. Bülau: Für die Heber Drainage bei Behandlung des Empyems, Ztschr. klin. Med. **18**:31, 1891.

tube and tight closure around it, that the lateral aspects of the wound healed by primary union, although no special attempt at sterilizing the wound was made. A similar observation often seen during the war was recalled, when wounds, if proper débridement was carried out soon enough after injury, most frequently healed by primary union. Why not go one step further, then, make a sufficiently large incision about the middle of the empyema cavity, add rib resection, clean out the cavity, select the best spot for permanent drainage, drain by the Kenyon or air-tight closed method and then tightly close the upper wound by immediate suture?

About this time, Binnie [4] presented some such idea, but without suggesting the immediate closure of the upper wound. In his article, he gives a most clean-cut and well thought out exposition of the problem of empyema. We went one step further.

This would give us, then, postoperatively, with the larger upper wound closed and the drainage tube inserted intercostally with its lower end under fluid, a potentially closed pleural cavity with the possibility for formation of negative pressure within it, after thorough visual and digital examination and evacuation of pathologic contents; surely, an ideal condition.

By using this method, during the first forty-eight hours after operation when the patient coughs, one can see bubbles of air expelled below with consequent slight rise in the column of fluid in the tube and the beginning of a push or pull on the diseased lung, peripherally. After that time, provided the upper wound is healing, the same procedure merely causes a current in the fluid in the bottle, easily discernible.

The value of careful exploration of the pleural cavity both visually and digitally is well illustrated in Case 2. Here a walled off secondary abscess was found between the base of the lung and the diaphragm. Such explorations and findings are impossible except with a large resected area of rib.

The question as to where the rib section should be made, anteriorly or posteriorly, to my mind makes no difference, as it *a priori* depends on how far forward or backward the empyema cavity extends. The technical difficulties encountered here or there, from thick masses of muscle, really amount to nothing. The main point is to gain entrance to the cavity.

The first opportunity to try out this procedure presented itself in March, 1921, and was successful in every respect. The upper wound healed perfectly by primary union, although all the contents of the empyema cavity, large quantities of pus and fibrin, were poured out

4. Binnie, J. F.: Treatment of Acute Empyema, Editorial Review, Arch. Surg. **2**:627 (May) 1921.

over the cut surfaces. The lower intercostal drainage wound, with tube, remained air tight for thirteen days. Had it not been for the misleading roentgen-ray reports, I am sure the total number of days of drainage would have been greatly reduced.

The cases recorded here are not selected. They represent every type of acute empyema coming to the service. As the technic of the operation was practically the same in the whole series, with only slight changes necessitated by individual peculiarities, the following method of procedure will serve as an example. In every case, the only anesthetic used was 0.5 per cent. procain with epinephrin.

OPERATIVE PROCEDURE

1. About 4 or 5 inches (10 or 12.5 cm.) of the sixth or seventh rib in the postaxillary line is resected subperiosteally, the intercostal nerve above and below the rib in question being blocked, and a diamond shaped area of soft parts above it.

2. Aspiration of the pleural cavity is carried out to insure that the incision is correctly placed for entering the abscess cavity.

3. A small knife stab is made through the bed of the resected rib and pleura, with immediate introduction of the metal suction apparatus, and the cavity is sucked dry.

4. The pleural incision is lengthened to the cut ends of the ribs. Thorough cleansing of the empyema cavity with physiologic sodium chlorid solution, poured from a pitcher and then sucked out follows. This is repeated until the cavity is clean. During this process, amazing masses of fibrin will come forth. In Case 6, one mass 8 by 12 by ¾ inches (20 by 30 by 1.9 cm.), covering the internal rib surfaces, came away with gentle traction.

5. Thorough visual and digital examination of diaphragm, collapsed or compressed lung, thoracic wall and pericardium is made if the empyema is on the left side. Examination is made for secondary pockets of pus, fibrous bands, etc.

6. The forefinger is introduced into the pleural cavity toward the angle of the ribs, to pick out the most suitable spot for permanent intercostal drainage. This spot must be at least one intercostal space above the diaphragm and as near the most dependent part of the cavity, with the patient in a semisitting position, inclining toward operated side, as is possible.

7. A rubber tube of suitable size with one side hole added is introduced through the intercostal space after a little 0.5 per cent. procain has been injected. This tube is tightly fitted through a large sized flat cork, and after a silk worm suture at either end of the stab wound to insure against leakage has been inserted, the cork is tightly pressed against the chest wall, having a thin layer of gauze between it and the

skin. A clamp is placed on the distal end of the tube, which is about 2 feet (61 cm.) long.

8. The upper rib resection wound is now cleansed and disinfected with plenty of 10 per cent. iodoform-ether solution, a sponge being held within the pleural cavity.

Fig. 1.—*A*, area of rib resection and line of incision through costal pleura; *B*, forefinger in pleural cavity marking point for drainage, one intercostal space above diaphragm, shown by dotted line; *C*, first layer of sutures, interrupted, through pleura, periosteum and deep muscle; *D*, second layer of sutures comprising external intercostal and latissimus dorsi muscles.

9. The wound is then closed in layers, a full curved needle and No. 2 plain gut interrupted suture being employed. The first layer comprises pleura (greatly thickened), periosteum and a bit of deep muscle.

Particular care must be given to the most lateral of the sutures in this layer to insure close approximation. In the second layer also interrupted plain gut is used, for closure of the intercostal muscles; in the third layer, continuous fine plain gut for the fascia; and, finally, silkworm gut for the skin. This gives a tightly closed wound, and of course no drainage of any kind is added. A dry dressing is applied.

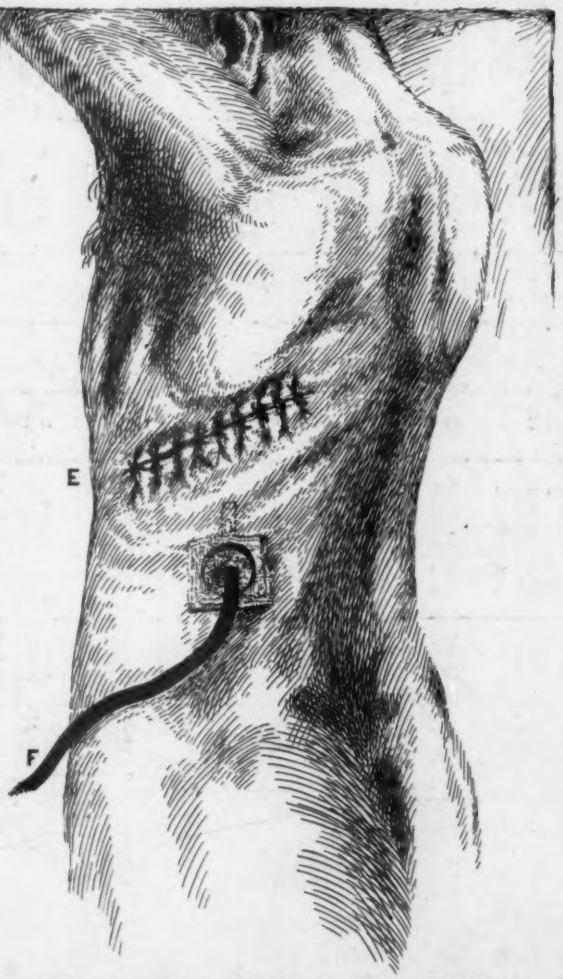

Fig. 2.—*E*, operation completed. Upper wound tightly closed—without drainage; *F*, tip of rubber drainage tube with side opening, through intercostal stabwound, seen within pleural cavity. The distal end of the tube should be clamped off until attached to bottle.

10. By means of interlacing and criss-cross 2-inch (5 cm.) adhesive plaster strips liberally applied, the cork is kept tightly pressed against the chest wall with the proximal end of the drainage tube firmly held within the pleural cavity.

TABLE 1.—*Summary of Cases*

Case	Age, Yrs	General Condition	Side Affected	Date of Operation	Findings—Pus				Drainage, Days			Rib Resection (Upper) Wound	Complications		Blood Culture	End-Result
					Amt., C.c.	Character	Fibrin	Organism	Air-tight	Open	Total		Pre-operative	Post-operative		
1. E. N.	23	Poor; acutely ill	Left	3/15/21	4,000	Thick, green-yellow	Very large masses	Streptococcus, short chains, nonhemolytic	13	37*	50	Primary union	Lobar pneumonia	—	Sterile	Cured
2. D. A.	6	Good	Right	3/ 2/22	250 and 120	Thin, green	Large masses	Streptococcus, nonhemolytic	23	7	30	Primary union	Broncho-pneumonia	—	—	Cured
3. E. U.	4	Fair	Left	3/ 6/22	250	Thick, green	Large masses	Pneumococcus	10	43	53	Primary union	Broncho-pneumonia	—	—	Cured
4. A. W.	4	Fair	Left	4/10/22	100	Thick, green	?	Streptococcus, short chains, nonhemolytic	5 (pulled out)	13	18	One wound sutured around tube; primary union at both ends	Acute rheumatic fever; broncho-pneumonia; otitis media	—	Sterile	Cured
5. C. R.	6	Fair	Left	4/25/22	1,000	Thick, green, odorless	Large masses	Pneumococcus and streptococcus, nonhemolytic	14	6	20	One wound sutured with tube at one end; primary union	Broncho-pneumonia; otitis media	—	Sterile	Cured
6. E. G.	23	Poor; acutely ill	Right	5/ 8/22	1,000	Thick, green	Very large masses, 8.7×12×¾ inches	Pneumococcus	2 (pulled out during delirium)	..	..	Primary union	Lobar pneumonia	Pneumococcus infection, left shoulder joint	Sterile	Died following decortication operation
7. M. G.	5	Fair	Left	6/ 3/22	750	Thin, green	Large masses	Streptococcus, short chains	13	6	19	Primary union	Broncho-pneumonia	—	Sterile	Cured

8. M. G. (Case 7)	..	Fair	Right	6/22/22	200	Thick, green-yellow	Small amount	No growth	7	9	16	Primary union	Broncho-pneu-monia			
9. J. F.	48	Very poor	Left	2/12/23	1,200	Thick, dirty green	A pus basin full	Streptococcus, short chains, nonhemolytic, and Staphylo-coccus albus	5	1	..	No attempt at healing; typically syphilitic	Broncho-pneumonia; myocarditis; Wassermann reaction 4+	—	—	Died, 7th day
10. A. S.	8	Good	Left	2/12/23	500	Thin, cloudy	Few parti-cles	Streptococcus, short chains, hemolytic	8	18	26	Primary union	Chorea and chronic endocarditis; broncho-pneumonia	Continued slight cough; neg. for T. B.	—	Cured
11. H. S.	38	Poor; acutely ill	Left	2/26/23	1,200	Muddy yellow; foul, colon-like odor	Large masses	Streptococcus, short chains, hemolytic and anaerobes, Gram + cocci, Gram — bacilli	9	53	62	Deep layers healed for primary union; subcutaneous secondary infection	Lobar pneumonia	—	—	Cured
12. W. B.	29	Very poor	Right	3/ 6/23	1,200	Thick, green	Large amount	Pneumococcus II	6	37	..	Only partially healed	Influenza; lobar pneu-monia	Acute sup-purative peric-ar-ditis; abscess, thyroid	Sterile	Died
13. R. L.	8	Fair	Right	3/16/23	500	Thick, green	Small flakes	Streptococcus, long chains, hemolytic, and Staphylococcus albus	10	20+	Ap-prox. 37	Primary union	Lobar pneumonia	Scarlet fever	—	Cured
14. M. H.	6	Poor	Left	3/17/23	500	Thin, green	Large masses	Streptococcus, short chains, hemolytic	9 (pulled out)	Pres-ent	..	Primary union; imme-diately pulled apart during fit of cough-ing; perfectly clean	Broncho-pneumonia	Measles	—	Wound still open

TABLE 2.—*Summary of Cases*

Case	Side Affected	Preoperative Blood Count	Normal Temperature (Postoperative) Day	Blow-bottles Begun, Days	Notes of Interest
1	Left	W.B.C. 20,000 Poly. 95%	2	9	12,000 c.c. drainage first 24 hours; by 18th day, size of cavity decreased from 4,000 to 150 c.c.; owing to roentgen-ray reports on 7th and 32d day after operation, of retained fluid, drainage tube left in place longer than necessary; fluid later found in stomach
2	Right	W.B.C. 22,000 Poly. 90%	4	8	Main cavity posterior; secondary abscess found between base of lung and diaphragm; drainage decreased from 150 c.c., 1st day, to 15 c.c., 11th day; roentgen ray, 6th day after operation, revealed marked improvement
3	Left	W.B.C. 6,500 Poly. 80%	3	6	Drainage 1st day, 100 c.c.; 10th day. 5 c.c.; on 17th day, drainage was profuse, so surgical solution of chlorinated soda was begun, with immediate marked increase in temperature, pulse and respiration, lasting 14 days; condition then improved, but enough drainage persisted to warrant continuous use of tube for 23 days longer; roentgen ray then showed lung well expanded
4	Left	W.B.C. 12,800 Poly. 78%	3	..	Sacculated empyema, lower anterior aspect of left upper lobe, with entire lower portion of left side of chest hazy and dull, indicating pleuritic involvement
5	Left	W.B.C. 28,800 Poly. 84%	5	..	Empyema was only one manifestation of a generalized infection; four aspirations done for relief; before operation could be attempted, lungs completely collapsed or compressed
6	Right	W.B.C. 14,000 Poly. 82%	8	9	Severe general infection; at 56th day, empyema cavity still could hold 650 c.c. bismuth oil, in spite of previous thorough flushing with surgical solution of chlorinated soda; on 65th day, resection of 6th, 7th, 8th and 9th ribs with decortication performed; continual increase in temperature, pulse and respiration; patient died 6 days after 2d operation
7*	Left	W.B.C. 29,600 Poly. 84%	..	..	Continuation of higher temperature, pulse and respiration rate than usual, with high blood count, led to conclusion that another focus of pus was present; found in right pleural cavity by physical examination and then aspiration; second operation 19 days after first relieved condition immediately
8	Right	W.B.C. 35,000 Poly. 80%	1	7	
9	Left	W.B.C. 18,000 Poly. 82%	Never	..	Operation gave free drainage but failed to improve general condition of patient, who remained apathetic, with weak pulse and great abdominal distention; generalized edema present over entire body except face, with a peculiar redness and tenderness in right flank; postoperative note, 4th day: " . . . primary union can hardly be expected because of preceding infection at site of rib resection due to former pleural paracentesis;" patient died suddenly
10	Left	.....	4	8	Drainage from 200 c.c. 1st day to 50 c.c. 4th day, still air-tight when removed; roentgen-ray report, 26th day, shows lung well expanded and in good condition, with considerable thickening of left lower parietal pleura
11	Left	W.B.C. 24,400 Poly. 91%	4	9	Foul odor of pus due to anaerobic bacteria; very large cavity, with marked infiltration of lung and thick, tough, adherent fibrin; drainage tube removed after 32 days; reaccumulation of pus on 37th day with reinsertion of tube; roentgen ray (bismuth) revealed pencil like sinus

*7 and 8 were the same patient.

TABLE 2.—*Summary of Cases—Continued*

Case	Side Affected	Preoperative Blood Count	Normal Temperature (Postoperative) Day	Blow-bottles Begun, Days	Notes of Interest
12	Right	W.B.C. 22,000 Poly. 91%	Never	..	(1) influenza; (2) lobar pneumonia, right; (3) acute suppurative pleurisy, right; (4) acute suppurative pericarditis; (5) abscess of thyroid; (6) infarct, left lower lobe immediately following blood transfusion; (7) death; both operations (thoracotomy and pericardiotomy) relieved the acute septic condition, but transfusion to hasten improvement caused the final untoward result; surgical solution of chlorinated soda left the pericardium marvelously clean from the beginning; wound inspection showed lung operated on in good condition, and a thrombus in large vessel to lower left lobe
13	Right	W.B.C. 20,000 Poly. 89%	4	8	Recovery; no rise in temperature, pulse or respiration after 4th day; on 20th day, scarlet fever developed; transferred to another hospital, where drainage tube was forgotten, then recovered and removed, with immediate closure of wound
14	Left	W.B.C. 11,000 Poly. 73%	5	8	Difficult case to understand; roentgen ray revealed constant shadow in upper portion of lower lobe next to pericardium; occasional marked rise in temperature; cavity became slowly smaller under surgical solution of chlorinated soda

11. The patient is brought to his bed and, before removal of above mentioned clamp, the distal end of tube is slipped over a glass connecting tube which is attached to a second rubber tube going through a close fitting cork into the bottom of a large glass bottle half filled with 1 : 5,000 mercuric chlorid solution.

12. The clamp is now removed. The patient is instructed to cough, and immediately the remaining contents of the empyema cavity with bubbles of air appear in the fluid—and negative pressure is being striven for.

One of the first questions asked when a different method of procedure is advocated is: Are the results better? Do you get quicker healing?

Our series is not yet large enough to permit of definite claims being made; but it seems that results are better and healing is more rapid. Taking the average total drainage days in the first ten cases, we find that healing was accomplished in twenty-nine days. The average time in the last five was only nineteen and nine-tenths days. It is interesting to compare this result with the latest statistics. Carl Eggers [5] states, "From a study of acute cases (empyema) it appears that healing usually takes place in from one to three months." Peck and Cave [6] say:

5. Eggers, Carl: Chronic Empyema, Ann. Surg. **77**:142 (Feb.) 1923.

6. Peck, C. H., and Cave, H. W.: Acute Suppurative Pleurisy, Surg. Gynec. & Obst. **36**:357 (March) 1923.

"Average cured time in ninety-four cases was sixty-three days." H. P. Brown, Jr.[7] writes: "Cured time, thirty-eight days."

The disadvantage of the method is the longer time required for operation, but in none of our cases was there operative death due directly to the operation. The advantages are: (1) a large opening, enabling digital and visual examination of pleural cavity; (2) thorough cleansing with removal of all free fibrinous masses and exudate; (3) the opportunity to pick out the best site for permanent drainage; (4) no need for postoperative dressings for at least a week; (5) the great comfort of the patient, without the usual marked dyspnea, and (6) reestablishment of physiologic conditions in the pleural cavities.

CONCLUSION

I wish to emphasize again that the postoperative course under the Kenyon or a similar method of drainage is a godsend to the patient. It is as different as day from night from the postoperative course in those cases in which the pleural cavity has been merely drained and left open. Any empyema operation is a trying one for the patient, particularly as far as its postoperative course is concerned, and it is our duty to ameliorate these conditions. To be able to give to these patients comparative ease in breathing; to do away with the constant terror of continuous dressings, and at the same time feel that the pleural cavity is clean and conditions are becoming normal is a goal to be achieved. We do not claim that this method of procedure is a panacea for all acute empyemas, or that it should be invariably employed; but we do feel that it is a step forward and that in our hands it has justified its expectations, and we hope that it will be tried by others.

DISCUSSION

DR. WILLY MEYER, New York: The fact that Dr. Pickhardt has brought this matter before our Association perhaps needs some slight explanation, because, as our first secretary, Dr. Green, brought out at the last meeting, it was the intention to exclude empyema from our discussions in connection with thoracic surgery, when this Association was founded, in 1917. We wanted to discuss the diseases and treatment of organs situated *beyond* the pleural cavity. However, as many of you will remember, the late Dr. Meltzer, when presiding over our first meeting in 1918, held that empyema should be a subject for our discussions. So we have ventured to bring it up again. What Dr. Pickhardt wanted to emphasize particularly, and what we personally consider a step forward in the treatment of acute empyema, is our ability to reproduce normal physiologic conditions, immediately after the chest has been emptied of all the contents due to the acute inflammation. We wished to work out a method, which would give us first a full view of the pleural cavity, and allow us to carry out necessary manipulations within it, besides thoroughly evacuating its contents, and then allow us to close the incision completely in layers, by

7. Brown, H. P., Jr.: Empyema Thoracis, Ann. Surg. **77**:401 (April) 1923.

means of sutures, under additional airtight drainage of the affected cavity. With the intercostal incision, we cannot place sutures so well. One needs firmer tissues overlying the pleura. We therefore considered it best to resect as long a piece of rib as possible, in the given case, stab and empty the empyema cavity of its fluid contents by suction, and then incise it widely through the bed of the resected rib. Now thorough inspection, intrapleural palpation and evacuation of all the masses of coagulated fibrin are feasible. After airtight insertion of the tube for drainage, as low down and as posteriorly as possible, without having to fear that the slowly rising diaphragm will interfere later on, and after careful disinfection of all the layers of the wound of the chest wall with a 5 per cent. solution of iodoform-ether, the incision is completely closed, while the end of the long drainage tube dips well into the fluid within the siphon bottle, which is placed under the bed.

As Dr. Pickhardt has explained, we perform most of these operations, on children as well as on adults, under local anesthesia. We are trying to avoid as much as possible general anesthesia of any kind in thoracic surgery. This operation certainly is a great improvement over the old Buelau method of trocar puncture and airtight tube drainage. In connection with the latter, we have repeatedly tried the Carrel-Dakin treatment, but found that the ultimate cure sometimes required many weeks, probably on account of the large amount of coagulated fibrinous material present, which even the chlorin solution often seems not to dissolve sufficiently. On the other hand, in one of our cases, Dr. Pickhardt could lift out from the pleural cavity in one mass the entire accumulation of fibrin, adherent as it was to the pulmonary pleura.

One word regarding the best place for inserting the tube for airtight drainage. If you look through the literature, you will find that, many years ago, Schede, while still at Hamburg, cured chronic empyema by placing a new drainage tube lower down. He emphasized the point that when operating for empyema we should always establish drainage in the lowest posterior place in the pleural cavity, in the open method, which had a good deal to do from the start in effecting a cure in the majority of cases. That is the thing we are trying to do by this method. With the finger inside, procain is injected at the selected place for drainage; skin and fascia are incised, and a blunt forceps is introduced and spread. A drainage tube of about the size of the third finger, and with two eyes near the end, is slipped through a narrower hole in the center of a thin piece of cork and is then introduced for about 1½ to 2 inches (3.7 to 5 cm.); and a few stitches are put in the skin. A split piece of gauze is slipped under the cork, which is held in place by two strips of adhesive plaster, 2 inches wide, running in different directions. Both pieces are split in part and cover also a part of the tube. The latter thus forms an absolute unit with the chest wall. The patient can turn and do anything he wishes, and he won't get that tube out. That is particularly important in cases of children. Of the further after-treatment you have heard. The wounds in these patients usually heal under one dressing, by primary union.

A girl of 15, well nourished, in whose case a layer of fat and muscle, quite thick, was divided, was treated by me in this way. Eight days after the operation, when the first dressing was changed and a smaller tube substituted for the large one, the wound had firmly healed by primary union. The cavity then held 45 c.c., while the patient had well over 1 quart (1,000 c.c.) of fluid in the chest at the time of the first incision. By airtight drainage, the lung had distended quickly. I am positive that most of us will have similarly satisfactory results. These patients sometimes continue for some time to have

higher temperature, in spite of free drainage. So it was in this case; but the general condition was good. For eight days, the temperature ranged from 103 to 104. I then changed dressing and tube, and employed the Carrel-Dakin treatment, and the temperature fell. I believe that if, in these cases of severe infection, we were to wash out the pleural cavity with surgical solution of chlorinated soda (Dakin's solution) repeatedly at the time of operation, instead of employing saline solution, we might perhaps avoid higher temperatures during the after-treatment, in almost every case. The procedure described by Dr. Pickhardt is perhaps as much as can be done on physiologic lines in cases of acute empyema.

Dr. George J. Heuer, Cincinnati: In analyzing a series of 450 cases of empyema recently, we found that the mortality in children under 2 years was between 25 and 39 per cent. In studying the pathology and necropsy records in these cases, it was quite evident that a large proportion of young people in later life have, at the time of the empyema, had grave complications such as unilateral or bilateral pneumonia, lung abscess, pericarditis, or something of that sort. In other words, the incidence of complications or complicating conditions at the time the empyema is treated was much higher in young children or infants than in young adults or adults. The mortality was the highest of all age groups, 39 per cent. We believe this was due to the production of pneumothorax at the time of operation. Since then, we have had a series of cases. I think we have now had in all twenty infants under 2 years of age with demonstrable pneumonia or some other complicating condition at the time of the empyema, with a mortality of 6 per cent. Whether that is due to a fortunate variation in the infection, I do not know. We have treated them simply by aspiration and suction drainage, without any incision at all. Whether this procedure would again increase the mortality by producing temporary pneumothorax is a question I should like to ask. The mortality has been so strikingly large in our series in which aspiration and drainage were employed that I should be loath to open the chest for the sake of getting out some fibrin clots. That procedure is to my mind of great advantage since it cleans out the thoracic cavity at the time of the operation.

I have had experience with the method of making a primary incision; opening the chest widely, and then closing the wound and draining elsewhere by aspiration drainage; and I can say also that, in the vast majority of cases, the primary incision heals in the presence of infection. I have had one unfortunate experience in the past year; in the only adult patient we have lost from empyema, we had opened the chest in a case of streptococcic empyema and had found no adhesions; in other words, it was not a localized empyema in the cavity in the sense that the visceral and parietal pleura were adherent. We drained below by aspiration and drainage. Promptly, the incision became infected; the chest wound opened widely, and in spite of all efforts to get it closed it would not stay closed; and the patient died from the open sucking pneumothorax. I am convinced that was the cause of death.

I should like to ask whether the essayist would advise this procedure in cases in which there is not a localized empyema; in other words, in the streptococcic empyemas we see occasionally, in which there is simply a single cavity without any adhesions apparently of the parietal and visceral pleura.

Dr. Nathan W. Green, New York: Dr. Pickhardt uttered a note of warning but did not accentuate the point that he would not perform this sort of operation in every case; he would select his cases. This note of warning should be heeded; for if one should perform this operation in every case, the

mortality would be greatly increased, as Dr. Heuer has surmised. I can recall one case in the last two years in which if I had done more than establish closed drainage, the patient, I am certain, would have died. These cases must be duplicated in the experience of others. Dr. Pickhardt, in sounding the note of warning in his paper, would do well to accentuate it by pointing out that this operation can be done only in a few selected cases.

Dr. Edward W. Archibald, Montreal: There are one or two questions I would like to ask Dr. Pickhardt and Dr. Meyer in regard to the mortality. I understood from their figures that there are only fifteen cases reported, a rather small series upon which to base mortality figures. I was led to believe from what Drs. Pickhardt and Meyer said that they include in their series only pneumococcus cases, in which there is a lot of fibrin, because they mentioned fibrin particularly; that they excluded acute influenza and streptococcus infections, which really ought not to be treated by large openings; and that they excluded also those very bad cases presenting complications like pericarditis or persisting pneumonia on one side or the other, or complications such as septicemia. The fundamental question is: Will this method reduce the mortality, in straight pneumococcus cases, below that which is customary in the ordinary operation of rib resection and open drainage? Will it reduce the time of healing as to the closure of the cavity?

Does Dr. Meyer allow the drainage opening to close while there is still a cavity, which he assumes to be aseptic, and which he expects to close later on under aseptic pneumothorax or aseptic pneumohydrothorax? Again, he has seen any wounds break down and give trouble?

In a review, made two years ago, of my cases seen over a period of about eighteen years, which number about eighty, in which operation was performed by the regular old classic method of rib resection and open drainage, I find I had a mortality of 12 per cent. I thought that was rather high, but on examining the pathologic reports, I found that nearly all these patients had died from severe complications, essentially fatal in their nature, such as acute septicemia, embolism, cerebral abscess, and even malignant tumor of the lung. Practically none of them died of the effects of the operation or of the effects of the empyema alone. There were only one or two that were left with chronic empyema. While I had to consider these results as far from brilliant, I was somewhat consoled in reading a late paper by Dr. Whittemore, of Boston, in which he compared the recent statistics of the Massachusetts General Hospital with earlier ones. The latter had shown a mortality of 20 per cent., whereas his late improved method had reduced it to the low figure of 12 per cent.

I should like to hear the opinions of the members as to whether we can really expect to reduce the mortality rate much below 12 per cent. by modern methods.

One other point: We are told that it is best to remove mechanically all the coagulated fibrin found in the pleura; but do we not thereby sometimes risk opening fresh paths of infection and causing acute reactions, as is suggested by the continued fever of 104 degrees for a week in one of the cases reported? In other words, will you risk aggravating a condition temporarily by mechanically removing the fibrin? My experience is that coagulated fibrin usually needs a fairly wide drainage opening for its evacuation. Much of it is slowly dissolved, but some must be gradually organized, leaving only a thickened pleura, but otherwise no damage. I think it is unwise to do much mechanical cleansing.

Dr. Conrad Georg, Jr., Ann Arbor, Michigan: Those of us who had experience with the treatment of empyema in the Army during the war will remember what a high mortality there was in the beginning, when many surgeons treated cases of acute empyema which were the result of influenza and streptococcus infection. In many cases there was a hemolyticus infection, so that the chest was filled within a few hours with an enormous quantity of fluid, and surgeons operated on these patients in the same way they did in their cases in civil practice when they had pneumococcus infections. They soon found the mortality was exceedingly high. When they set to work to resect a rib in the acute cases, they produced pneumothorax at once, because there was no walling off of the abscess; so that subsequently, when the empyema commission investigated the subject, it was found a great deal better to resort to the closed treatment; to aspirate the pleural cavity, and then to close the puncture. Subsequently, after the abscess was walled off, and the patient's condition warranted the operation, a rib was resected. A radical operation in the beginning of the treatment in such cases was found to be invariably attended by a greater mortality.

The operation described by Dr. Pickhardt would be proper in cases of pneumococcus infection when we have walling off of the abscess, but when we have cases of hemolyticus infection, in which there is the formation of a large quantity of fluid, but no walling off of the abscess, it is far better to use the closed method and resort to open drainage when necessary.

In one case in my experience during the War, a man had had an empyema in which healing had been complete, and he was ready to be discharged from the Army. We took a roentgenogram of the patient before his discharge and found there were two drainage tubes in the pleural cavity, although the wound had entirely healed. He had to have another operation before he could go home.

Dr. E. F. Butler, Sayre, Pa.: Every one who has spoken has emphasized the difference between streptococcus and pneumococcus empyema. I also want to add a note of warning and ask Dr. Pickhardt whether prior to this operation a bacteriologic diagnosis was arrived at, and whether the streptococcus cases were purposely excluded or whether they were included in the series.

As Dr. Georg has well said, this seems to be an admirable procedure for the pneumococcus type of empyema, but it would be a dangerous one for the streptococcus type, particularly the early streptococcus case in a young patient.

Dr. Howard Lilienthal, New York: I approve the principle of this operation as described by Dr. Pickhardt. In 1914, I described an operation in which inspection of the cavity could be made through an intercostal incision without dividing a rib. As a rule, the division of the ribs is not necessary in these cases. It predisposes to osteomyelitis. It is only necessary in the chronic cases in which there is rigidity of the chest wall. The air tight drainage is advisable for the first few days after operation although patients have been operated on with complete immediate disinfection of the entire cavity and with absolute closure of the chest resulting in primary healing. The kind of organism present is a great factor—the streptococcus being the one most difficult to deal with. I agree with Dr. Georg that we should not forget the teaching of our Army Empyema Commission and that no thoracotomy should be performed until there is reason to believe that the mediastinum is rigid. Althought the streptococcus is a dangerous organism to deal with, walling off before drainage by incision is more important than the character of the germ present. If the pyogenic cavity has distinct walls, the patient will recover after proper drainage regardless of the infecting organism. In another class of empyemas, we have to do

with anaerobic infection from a lung abscess which acts as a focus. Here, of course, it would be dangerous to close the chest even with airtight drainage, for the anaerobic organisms of gas gangrene would probably infect the chest wall, with fatal result. It has been my rule to make an intercostal incision with or without airtight drainage, and, if the patient does well, to avoid further procedures. If, however, within from five to nine days, there are evidences of absorption a roentgenogram should be made, and an explanation of the condition may be found in the presence of a pneumonia or possibly one or more other abscess cavities. The wider intercostal incision is then made, with the radical treatment of conditions in the chest as they are found. About 33 per cent. of the patients will get well as a result of intercostal incision alone.

Dr. O. C. Pickhardt, New York: I think I mention that our series of cases was too small to warrant forming any definite opinion or making up any statistics. The paper is more in the nature of a preliminary report and the operation will need considerable trying out before one can make any definite statements. We performed no operations in children under 2 years of age; therefore I cannot answer Dr. Heuer's question. The mortality of the children we operated on was nil. We lost two adults. Our first fatal case was that of a very fat woman, 50 years of age, who was very sick. We should not have attempted this operation because the wound site was already infected, owing to aspiration of the chest before operation. We dressed the wound on the fifth day and found that it had not even begun to heal. The woman had a four plus Wassermann reaction, and the appearance of the wound was typically syphilitic.

The other case was interesting as illustrating the sequence of influenzal pneumonia empyema. The patient was operated on for empyema, and developed an acute suppurative pericarditis, which was recognized two weeks later. I performed a pericardotomy, and the man, who was 29 years of age, was doing nicely. He was a private patient, and the family was very insistent on a speedy recovery. We transfused 600 c.c. of citrated blood, and shortly afterward the patient expectorated blood and died. A wound inspection was permitted and we found an embolus in the left lower lung. I believe that this patient would have recovered, if transfusion had not been performed.

We did not exclude any cases in the series that came up. We found that the streptococcus type was just as frequent as the pneumococcus. There were several cases of the *Streptococcus hemolyticus* type.

During the War, most of the empyemas were merely one manifestation of a generalized infection, and when we had similar cases here, we naturally did not operate immediately. We waited two or three weeks until conditions were ripe, and then we performed this operation, with good results.

MALIGNANT TUMOR OF THE LUNG: NECESSITY FOR EARLY OPERATION

HOWARD LILIENTHAL, M.D.
NEW YORK

Interest in the surgery of thoracic infections has brought about great advances in the past few years and the War has taught us much in methods of operating in recent wounds of the chest, and their postoperative management. We feel that standardization in these matters is well on the way, and that it will not be many years before thoracic surgery, recognized as a true specialty, will occupy a position akin to abdominal surgery, both in the indications for operation and in the varieties of recognized technic. Even the mediastinum has yielded to persistent assaults on its secret places, and the surgery of this important space need no longer be complicated by the dangers of pneumothorax and pulmonary collapse. Its most important organ surgically speaking, the esophagus, is still in the background so far as successful results go in the treatment of its disorders, but I feel sure that recent methods of approach and the earlier diagnosis of disease will be followed by more and more frequent successes.

There is one malady which is found within the chest which has not received the attention it deserves: the malignant neoplasms of the lung. I cannot picture a more distressing and hopeless condition than pulmonary cancer at a time when it usually reaches the hands of the surgeon. There is not only the primary malignant focus, but nearly always, extension to the neighboring parts and secondary suppuration, either within the tumor itself, from necrosis with infection, or in a lung abscess with suppurative bronchiectasis from occlusion or compression of the bronchial tubes. The complications of the cancer are almost as difficult to treat and as dangerous to life as the original disease.

Probably because of tardiness of recognition, few cases of lung cancer have been treated by radical surgery and still fewer by successful extirpation;[1] but volumes have been written on the pathology of lung cancer and its melancholy course, beginning with the early history of the case and ending with that final proof of failure, the postmortem

1. Five cases in which a radical operation was attempted are reported from the clinic of Sauerbruch (Chirurgie der Brustorgane, Zweite Auflage, 1:850). One of his patients was alive five years after the extirpation of a carcinoma of the left lower lobe, and one was living three years after the resection of a carcinoma of the right lower lobe in which part of the diaphragm had to be sacrificed as well. A very few other writers have reported attempts at operation in these cases, most of them failures.

examination. Surely with all the time and study which has been given to this subject, it is strange, almost inexcusable, that patients are not sent to the surgeon at least early enough for exploratory thoracotomy. Seldom have I seen the diagnosis made until months of painstaking study and minute observation have resulted in time lost and opportunity for cure thrown heedlessly away. If operation is to promise anything more than corroboration of the clinical findings and perhaps a little relief, it should be performed as soon as possible after the earliest suspicion of cancer. We have at our command facilities for making a prompt working diagnosis, or even an accurate pathologic one, but the medical profession is nearly always slow to avail itself of new diagnostic procedures of a surgical nature. I have seen weeks or months wasted in purely clinical (?) examinations, leaving so harmless and accurate an adjunct as roentgenography to be used at last merely as a means of confirmation, instead of in the beginning, to show at least the location and size of the lesion. Following roentgenology, bronchoscopy with the removal of a specimen will often turn doubt into certainty, to the great advantage of all concerned. But bronchoscopy, except for the removal of aspirated foreign bodies, is unfortunately too little known by the mass of the profession, and they regard it as in itself dangerous; whereas in fact it is not so liable to be followed by untoward sequelae as the more widely recognized cystoscopy.

Now let us see how these two great diagnostic aids may be employed as time-saving and life-conserving agents; first, however, reviewing briefly the anatomic pathology and the clinical manifestations, including the symptoms of early, probably operable cancer of the lung.

PATHOLOGY

Cancer of the lung may begin in some part of the bronchial system, usually at a secondary fork, or it may start in the parenchyma of the organ. The cells in the former type, derived from the bronchial mucous membrane, show cylindrical or cuboid forms; while pavement cells are characteristic of the parenchymatous cancers. In the bronchial type, the symptoms which should lead to the suspicion of malignancy begin with early cough because of the endobronchial irritation. The cough is dry at first; then a small amount of glairy sputum is raised, followed by pink sputum mixed with saliva. Rarely, there may be actual hemoptysis. This train of phenomena changes when the lumen of the tube becomes obstructed and bronchiectatic dilatation develops, with profuse discharge, quickly becoming putrid. Peribronchial abscesses and suppurative pneumonitis are further complications which are pretty sure to arise. By this time, the diagnosis without an accurate antecedent

history will be only too apt to rest with the verdict of suppurative bronchiectasis, and the primary cause of this condition may be long overlooked.

In contrast to the primary bronchial neoplasm, cancer which begins in the alveolar portion of the lung may not at first show symptoms

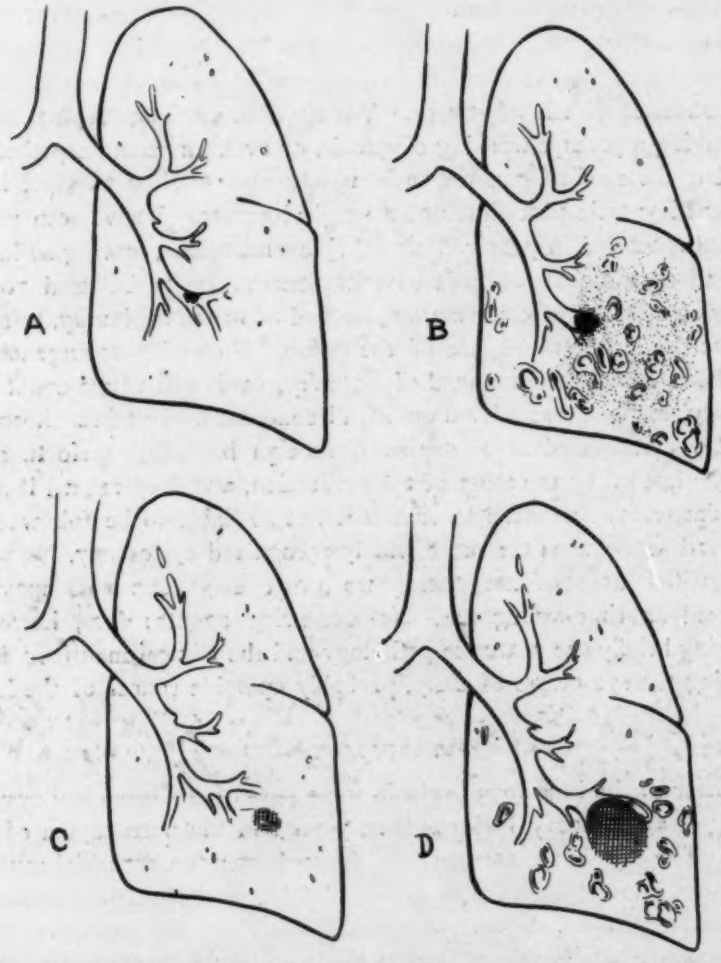

Fig. 1.—*A*, early tumor of bronchial wall, not greatly reducing the lumen, invisible by roentgenoscopy, but clearly seen through the bronchoscope. Specimen may be removed; an operable condition. *B*, the lumen greatly reduced or even occluded by progressive growth; secondary bronchiectasis visible by means of roentgen ray. Accurate diagnosis is possible by the bronchoscope. There is surrounding infiltration. The condition is inoperable except for relief. *C*, small parenchymatous growth seen by means of roentgen rays but not otherwise demonstrable; operable. *D*, larger growth in parenchyma pressing on bronchus from without and causing secondary bronchiectasis. Accurate diagnosis is possible by means of endoscopy when the tumor has broken into the bronchus; inoperable except for relief.

pointing toward a pulmonary lesion of any kind, and the earliest apparent sign of the disease may be the cough which accompanies secondary invasion of the bronchi by direct extension; or the tumor may become large enough to occlude a bronchial branch by pressure from without, when bronchiectasis will develop, with its usual repulsive train. These parenchymatous cancers may grow to a large size before suspicion of a thoracic disturbance of any kind is aroused, just as the

Fig. 2.—Appearance of chest in a case of metastatic parenchymatous flat-celled cancer. The tumor was already very large when attention was directed to the thorax as the seat of disease.

lung metastases from a distant focus of malignancy may involve the pulmonary tissue to a remarkable degree with small or large spherical masses of cancer not discoverable without roentgenoscopy. So long as the bronchi are uninvaded, cough, dyspnea, cyanosis or other striking phenomena will usually be absent, and the ordinary physical signs may be so insignificant as to test the skill and acumen of the very elect.

Primary tumors of the parenchyma may occupy a surprisingly large portion of the lung, with no indication that function has been impaired

and with only a general deterioration in the patient's health to show that anything is wrong.

The schematic drawings (Fig. 1) illustrate the early conditions as well as their subsequent progress in both the bronchial and the parenchymatous types of the disease. Figures 3, 4 and 5 present the roentgenographic appearances in cases of parenchymatous lung cancers.

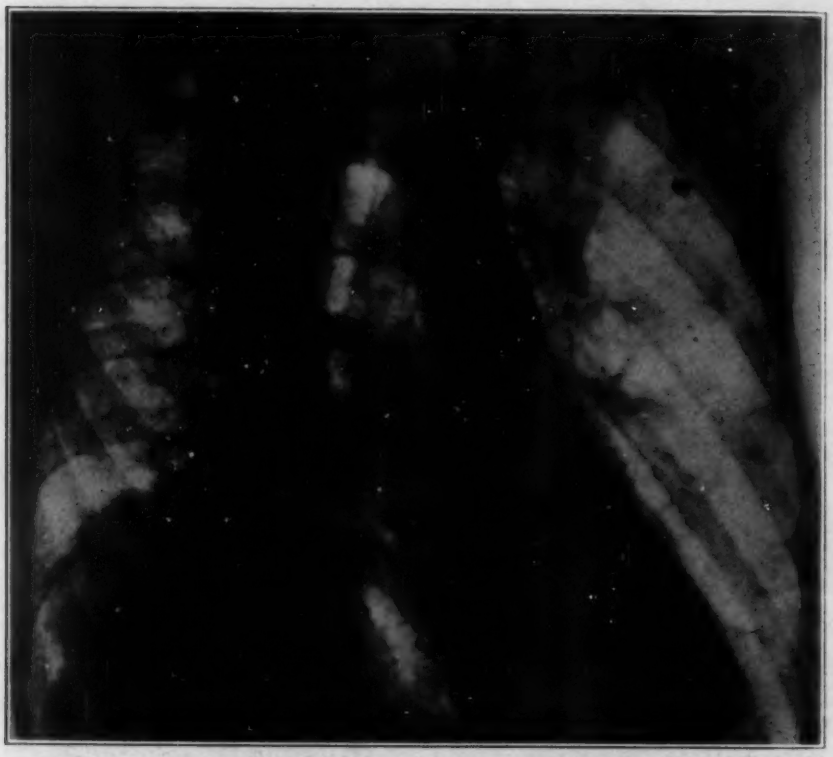

Fig 3.—Another view of the case shown in Figure 2.

DIAGNOSIS BY ROENTGEN RAY AND BRONCHOSCOPE

The most casual scrutiny of the diagrammatic pictures must make perfectly clear what can be accomplished by operation and when it should be undertaken.

Roentgen Ray.—The clearly marked circular shadows of parenchymatous infiltration by cancer will appear very early in the development of the disease; far earlier than the ear can detect changes by percussion or auscultation. Whether we are dealing with cancer or not, we have found something which must be explored. A lump of similar size in the breast of a woman would call for immediate operation; surely, a lump in the parenchyma of the lung calls for no less. It can be only

timidity which would lead to delay; and yet, a wide intercostal thoracotomy, with perfect facilities for seeing and handling the lump, is not in itself a perilous procedure; and it stands to reason that the removal of an uninfected pulmonary lobe is far less risky than a similar extirpation after breaking-down and suppuration has complicated the case.

Fig. 4.—Primary carcinoma of lung which has already broken into the bronchus. The patient was treated for tuberculosis.

It is my firm conviction that such early lobectomy would be fully justified and that the time is not far distant when this generation of surgeons will be severely criticized for not urging operation before it is too late for complete removal of the growth. Lobectomy in such a case, without anaerobic infection and suppuration, is surely a very different thing from ablation in a foul bronchiectasis. The lobe of a healthy dog can be removed with ease and safety and the conditions would be similar in an early peripheral, parenchymatous, uncomplicated cancer in man. To wait for the tumor to invade a bronchus will be

to lose the best, perhaps the only, chance for successful extirpation. The ease with which these parenchymatous growths may be attacked will be in direct proportion to their distance from the hilum, and it is quite conceivable that a peripheral tumor of this kind, not too large, may be extirpated with a wide margin of healthy lung, even without the removal of the entire lobe, the added dangers of dividing large vessels and bronchi near the root of the lung being thus avoided. A technic will perhaps be devised with increasing experience, permitting the chest to be closed, in some of these cases at least, without drainage.

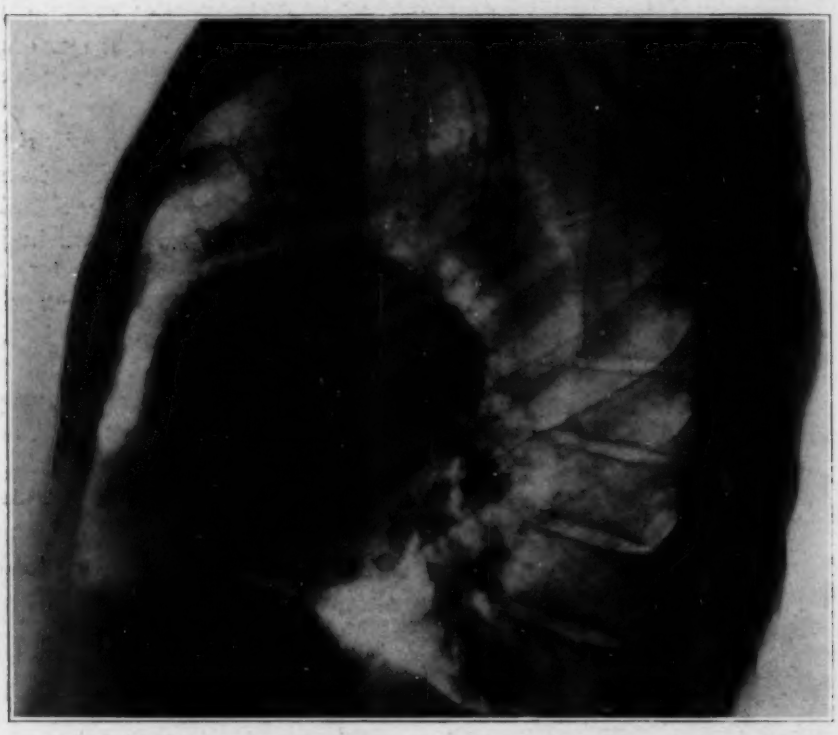

Fig. 5.—Another view of the case shown in Figure 4.

But this aspect of the question is of secondary importance as compared with the wide extirpation of the growth.

Bronchoscopy.—Now let us consider the other important form of lung malignancy which begins in the bronchial wall. As stated above, the favorite location of these tumors is at the secondary branching of the tree; in other words, these cancers usually begin at a considerable distance from the main bronchus of a lobe. Here the roentgen-ray examination will show nothing recognizable until occlusion of the air passage has gone far enough to bring about dilatation and perhaps

infection of the distal distribution of this branch. Then the triangular shadow representing the cone of involvement will be clearly seen (Fig. 6), resembling the shadow in cases of plugging by a foreign body. While it is true that roentgenography will not demonstrate these early tumors, bronchoscopy not only yields the information derived from a clear view of the growth itself but also will permit the removal of a

Fig. 6.—Primary lymphangiosarcoma (Mandlebaum) of bronchus with characteristic triangular shadow from secondary bronchial and parenchymatous infection. The apex of the triangle is usually on the mediastinal side.

specimen for histologic examination. When there is dry cough, often spasmodic, gradually increasing in severity; when the sputum appears, finally tinged with blood, the diagnosis of new growth of the bronchial wall should come to mind at once. As soon as this suspicion is aroused, there should be no delay in the endoscopic examination. Thus we may

hope to recognize with absolute certainty the presence of incipient cancer long before the condition becomes obscured by bronchial or even pulmonary suppuration. Radical operation in an early case of this kind would be almost as simple from the technical point of view as in the parenchymatous variety which we have just been discussing. The extirpation of the entire lobe when the pedicle is one or even two branches away from the site of the tumor should give an excellent chance for permanent cure.

I repeat, this is not the time to discuss the details of operation, but every surgeon will recognize that instead of the 50 per cent., more or less, mortality which follows lobectomy for abscess, the danger should be tremendously decreased when we are dealing with normal or comparatively normal tissues. To be sure, the danger of infection is present even from a healthy open bronchus, but also there is danger of infection when a normal vermiform appendix is cut away. Surely, it should not be difficult to work out a safe technic for this kind of lung surgery. The fear that we may be about to try conclusions in an inoperable case need not deter us; for, in the purely exploratory operations, I have found that even when the case has appeared hopeless, good has been accomplished, apparently by the mere opening of the thorax. Whether this has come about through collapse of the lung or from some other cause is unknown to me. In cases complicated by embarrassment due to quantities of fluid, I have seen relief following a free exploration with drainage, the wound in the chest finally closing and the fluid not reaccumulating. In other cases, cough has been greatly relieved, and in no instance have I seen any evil effect from the thoracotomy.

CONCLUSION

I have taken this opportunity to present the subject of early operation in lung cancer because this Association will radiate its educational influence to all parts of our country and beyond its confines. We have before us the same task which confronted the surgeon in the early days of appendicitis. Surgeons should emphasize the great necessity for early recognition and early action in cancer of the lung just as in cancer anywhere else. I have the added advantage, too, of addressing a group which contains representative men in nearly all the branches of medicine which deal with diseases of the lungs. We have among us physicians, surgeons, peroral endoscopists and roentgenologists, and it is only by working together in the advancement of these great problems of pulmonary disease that we shall finally succeed. The opportunity today is ours, and I hope and believe that another year will bring reports of success in this almost untried branch from the Fellows of the American Association for Thoracic Surgery.

INTRACARDIAC SURGERY

DUFF S. ALLEN, M.D.
ST. LOUIS

A new method for carrying out surgical procedures inside the cavities of the heart was described in our preliminary report.[1] Only the method for carrying out these intracardial surgical procedures was discussed. Since the method is new, we shall describe it again, and, in addition, discuss some of the effects on the heart and the two circulations subsequent to carrying out certain of these procedures on the mitral valves.

METHOD

We have approached the problem of intracardiac surgery from the point of view of the surgeon. Our aim was to develop a practical method for carrying out surgical procedures inside the cavities of the human heart. We were not satisfied, therefore, with any method that would be useful in the experimental laboratory but that was clearly not applicable in the operating room. This distinction is important.

From the beginning of this experimental work, we believed that such operations, if they were to be applied to the human heart, must be carried out under the guidance of vision. Haeker, Carrel and Tuffier and others had attempted the development of a method for carrying out surgical procedures inside the heart under direct vision by clamping off the pedicle of the heart and thus working in a bloodless field. They had found that two and one-half minutes was all the time allowable for carrying out these operations on the normal heart of the dog. Their success was not marked.

We made attempts, therefore, to lengthen the two and one-half minutes by perfusing the heart, with a view to following this method. We were not successful. One day, however, we noticed that, when a heart was immersed in a bloody fluid contained in a glass jar, wherever the heart came in contact with the glass, the details of the outside of the heart could be seen distinctly even though it was in an opaque bloody medium. This suggested that if we could get a piece of glass against the inside wall of the heart, we could see it while the circulation was taking place through the heart. The result has been the development of the cardioscope, which permits a direct view of the inside of the

1. Allen, D. S., and Graham, E. A.: Intracardiac Surgery, J. A. M. A. 79:1028 (Sept. 23) 1922.

heart while circulation through it is going on. Operative procedures, therefore, can be carried on inside the heart under direct vision while circulation is taking place and without any necessity for undue haste.

SURGERY OF THE MITRAL VALVES

In this study of the surgery of the mitral valves, especial consideration should be given: (1) the route of approach through the heart muscle to reach the mitral valve; (2) the immediate and later effects of the procedure on the heart itself; (3) the effects on the systemic circulation, and (4) the effects of regurgitation and stenosis of the mitral valve on the pulmonary circulation.

1. The route of approach through the heart wall to reach the mitral valve is of importance. In our earliest experiments, we found that more than 50 per cent. of the hearts stopped during the operation when the cardioscope was inserted through the wall of the left ventricle to reach the mitral valve. This high mortality was found to obtain, even though great care had been used to avoid the larger branches of the coronary arteries of the left ventricle.

We then began a series of experiments in which the approach to the mitral valve was through the left auricular appendage. This structure is remarkably well suited for the introduction of the cardioscope, both from an anatomic and from a physiologic point of view. It is a sort of thimble shaped structure which comes off the side of the left atrium. The left auricular appendage seems to have little physiologic function. It can be manipulated in the most severe manner without greatly disturbing the heart as a whole. We have had no mortality due to manipulation incident to inserting the cardioscope through the left auricular appendage.

The cardioscope is inserted into the left auricular appendage thus:

> A weak-jawed clamp is applied to the appendage at its base; then, the tip of the appendage is grasped by two forceps and incised sufficiently to permit the introduction of the end of the cardioscope. A purse string suture is now placed around the middle portion of the appendage and the cardioscope is inserted and tied into place. The clamp at the base of the appendage is then removed and the lens end of the cardioscope can be passed into the left atrium or into the ventricle. The mitral valve can be distinctly seen and definitely identified. With the knife attachment, as described in our preliminary report, one can easily cut the mitral valve under direct vision, and while the circulation is taking place through the heart.

We feel that the function of the left auricular appendage is negligible. We have not been able to demonstrate any ill-effects from the amputation of it, and it has been our routine procedure to ligate and amputate it at the close of the operation in order to prevent formation of a postoperative thrombus within it.

2. The immediate and later effects of the procedure on the heart itself have been one of our many surprises in this experimental work. We have followed our experiments for as long as eleven months after cutting the mitral valve. This has been done by observations of the general condition of the dog and electrocardiographic studies of the

Fig. 1.—A photomicrograph of a section taken through the base of the left auricular appendage, two weeks after the operation through it; *a*, endocardium; *b*, new endocardium; *c*, the silk ligature.

heart itself. During the operation, surprisingly little disturbance can be detected on observing the heart with the eye. A few extra systoles are the most marked abnormalities that we have noticed.

After the operation, we have found that the base of the left auricular appendage heals perfectly. There has been no suture material

placed within the cavity of the heart and the endocardium has been placed in apposition with the endocardium by simple ligation of the appendage. Figure 1 is a photomicrograph of a section taken through the base of the appendage two weeks after the operation, showing that the wound in the heart wall heals without thrombus formation about it.

Fig. 2.—A photomicrograph of a section through the cut edge of a mitral valve at the end of twenty-eight days; *a*, thickening of the valve leaflet immediately adjacent to the cut surface; *b*, endocardium, which has completely covered over the cut surface. There is no thrombus formation.

The cut in the valve itself does not grow back together; nor is there a postoperative thrombus formation on the cut edges of the valve (Fig. 2). One would expect a certain percentage of these valves to have vegetation-like thrombus formations on the edges, but this has not

been the case. The endocardium begins to grow over the cut edges of the valve, and in a short time has completely covered over the raw surfaces, leaving the size of the original split in the valve practically unaltered. In the experimental dog which we allowed to live for eleven months, we found that the split in the valve extended back upon it as far as its attachment to the heart wall.

Electrocardiographic records have been taken before operation, immediately after operation and at intervals up to as long as 251 days after the operation. Since we had gone through and amputated a portion of the left auricle to reach the mitral valve, our first concern was to know whether the function of the left auricle had been greatly disturbed by the procedure. Was the left auricle still beating after the operation? If so, was it beating regularly? Were the auricles beating together, and, if so, were they able to set the pace for the ventricle? Our electrocardiographic records show that the auricle beats regularly after the operation, and the interval between auricular systole and ventricular systole is well within the normal time limit. The ventricle follows the auricle in an essentially normal manner.

3. A most important factor in surgery of the heart is its immediate effect on the systemic circulation, because the circulation to the central nervous system must be maintained at all times. We believe that the dangers of operative procedures on the heart which have been described by others are due to the interpretation of the blood supply to the central nervous system and not to the interruption of the blood supply to the heart itself. The heart is able to withstand severe traumatism. We have succeeded in transplanting the living heart from one dog to another. The circulation to the central nervous system can be shut off for only about two and one-half minutes with recovery of the animal. Our method permits the circulation to the central nervous system to be maintained throughout the entire operation.

Kymographic tracings of the blood pressure in the femoral artery taken during the operation reveal a slight fall in blood pressure at the time of clamping the auricle. This pressure is maintained at a constant level until the end of the cardioscope is placed in the atrium, when a further lowering of blood pressure is noted. This lowered blood pressure continues until the end of the cardioscope is drawn back into the left auricular appendage, when the pressure abruptly arises again. If a regurgitation has been produced, the blood pressure in the systemic circulation does not immediately rise to its former level. With a regurgitation through about 25 per cent. of the total area of the mitral valve, the blood pressure in the femoral artery is found to have fallen 10 per cent. At no time during the operative procedure do we find an alarmingly low blood pressure. The lowest noted in our record was maintained for only 39 seconds.

Figure 3, a kymographic tracing of the blood pressure in the femoral artery in one of these experiments, during the operation, shows the abrupt falls and rises in the blood pressure of the systemic circulation. It indicates that if one wishes to bring the blood pressure back to what may be considered the normal during the operation, one has only to withdraw the end of the cardioscope into the left auricular appendage, a matter of one or two seconds.

4. The effects of regurgitation and stenosis of the mitral valve on the pulmonary circulation are significant in a consideration of the feasibility of the relief of mitral stenosis by surgical means. Clinically, these patients with mitral stenosis suffer greatest from the upset in the pulmonary circulation. The questions of paramount importance, then, are what is the effect on the pulmonary circulation of a mitral stenosis,

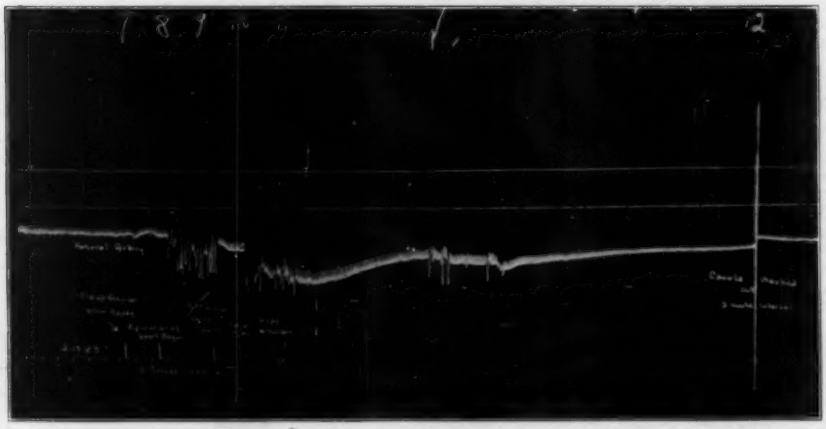

Fig. 3.—A kymographic tracing of the blood pressure in the femoral artery in one of these experiments, during an operation for cutting the mitral valve. It shows a slight fall in the mean systemic pressure before cutting the valve and a more marked fall following the production of a severe regurgitation. The systemic blood pressure tends to return to the normal after the production of a sudden regurgitation, but does not return immediately.

and what is the difference between the pulmonary circulations in mitral stenosis, mitral regurgitation and the normal. It is logical to consider these differences as mainly between the degree and the type of back pressure in the pulmonary circulation. They are most marked immediately behind the mitral valve itself, that is, in the left auricle, and can be best measured there.

For several months we have been able to produce a mitral stenosis by laying a loop ligature inside the heart in such a manner that it will surround the chordae tendineae at the point of their attachment to the edge of the mitral valve. When this is tied, the valves can no longer

open during diastole, and a real stenosis, mechanically, of the valve results. This ligature can be gradually or suddenly tightened to produce a gradual or a sudden stenosis of the valve. We have succeeded in producing a stenosis sufficient to give an engorgement of the left auricle, followed by an auricular flutter, and finally auricular fibrillation. These changes in the left auricle could be observed by the eye. They are a reproduction of the progressive heart-picture of mitral stenosis clinically. Respiratory difficulty was noted during the experiment.

A comparative study of the left intra-auricular pressures and the normal, the stenotic and the regurgitating mitral valves is most accurate if the data is obtained from the same heart and under the same experimental conditions. We have been able to record the intra-auricular pressures in each of these conditions in reasonably quick successions and in the same heart.

Fig. 4.—A kymographic tracing of the left intra-auricular pulse pressure and comparative mean pressures with a severe mitral regurgitation and with a severe stenosis plus a slight regurgitation; showing that the back pressure in the pulmonary circulation is higher and of a less intermittent type in a severe stenosis with slight regurgitation than in a severe regurgitation.

As compared to the normal, the left intra-auricular mean pressure in mitral stenosis is found to rise. The increase in the diastolic pressure is greater than the increase in the systolic pressure. The pulse pressure in the left auricle, therefore, is less in mitral stenosis than in the normal. As compared to the normal, the left intra-auricular mean pressure in mitral regurgitation is found to rise also; but the increase in the systolic pressure is greater than the increase in the diastolic pressure and, therefore, the pulse pressure in the left auricle is greater in mitral regurgitation than in the normal. These fundamental pressure differences will be described in detail in a future communication.

From the point of view of the surgeon, the question as to whether the pulmonary circulation in a patient with a marked mitral stenosis

plus a slight regurgitation would be benefited or not by changing the stenosis into a regurgitation is a pertinent one. Clinically, the usual mitral stenosis is accompanied by a regurgitation. It is not at all unlikely that, in many of these cases, the operation of splitting the mitral valves to relieve the stenosis would not relieve the regurgitation as well, but would even increase it. Could we then expect an improvement in the pulmonary circulation? Our experimental data indicate an answer.

Experimentally, it is possible to produce a mitral stenosis plus a slight regurgitation. In Figure 4, a kymographic tracing of the left intra-auricular pulse pressure, a section of a marked stenosis plus a slight regurgitation is interposed between two sections of marked regurgitation. The last two sections of the record show, therefore, a condition of a marked stenosis plus a slight regurgitation which has been suddenly changed into a regurgitation.

Coincident to these changes in the mitral valve lesions, changes occur in both the degree and the type of left intra-auricular pressures, in the back pressures to the pulmonary circulation. With the mitral stenosis plus regurgitation, the mean back pressure is high and of a continuous type; while in the marked regurgitation, the mean back pressure is not so high and of an intermittent type.

One cannot fail to notice the marked lowering of the diastolic pressure in mitral regurgitaion as compared with stenosis plus regurgitation. We know that the blood flows from the pulmonary circulation into the left auricle during its diastolic phase. We should expect, therefore, to find a greater interference with the pulmonary circulation in mitral stenosis plus regurgitation, than in mitral regurgitation. Clinically, this is known to be true. Moreover, we should expect to relieve this circulation by changing a marked mitral stenosis plus a slight regurgitation into a marked regurgitation. It is hardly necessary to add that we would expect a greater improvement in the pulmonary circulation if we should change the stenosis plus a regurgitation so that there would be normal function, and that any result between these two extremes—marked regurgitation and the normal—should improve the pulmonary circulation.

SUMMARY

Our experiments show that we can carry out surgical procedures inside the cavities of the normal heart of etherized dogs under the guidance of vision with impunity and without undue haste or interruption of the circulation.

In operations on the mitral valves, the approach of choice is through the left auricular appendage. Following cutting of the mitral valve, a surprisingly small number of changes are to be noted in the heart's

action; the wound in the wall of the left auricle heals perfectly, and the split in the valve does not grow back together.

The back pressure to the pulmonary circulation is of a constant type in mitral stenosis and of an intermittent type in mitral regurgitation. The mean back pressure to the pulmonary circulation is higher in a marked mitral stenosis plus a slight regurgitation than in a marked mitral regurgitation. If we should convert a mitral stenosis into a regurgitation, the pulmonary circulation should be improved. More improvement in the pulmonary circulation would be expected if we should convert the stenotic mitral valve into a functionally normal valve.

DISCUSSION

Dr. Howard Lilienthal, New York: This is a most extraordinary and romantic exposition. I am glad to think that I have lived to see this remarkable work of Drs. Graham and Allen.

Dr. John L. Yates, Milwaukee: Having seen this work, I can fully appreciate its value from a surgical standpoint. One question has occurred to all: Will division of a stenotic mitral valve ring afford permanent release or will the healing process reestablish the stenosis? Dr. Allen's studies indicate that raw surfaces created by incisions endothelize so rapidly that release will be permanent. It is only a question of time before Dr. Allen will be able to relieve pathetic cardiac cripples permanently and with relative effectiveness, provided patients are referred while they still possess some reserve power in the heart muscles.

I think it is rather difficult to overestimate the value of this work, and I wish to congratulate Dr. Allen on both the extraordinary excellence and the practicability of his contribution.

Dr. Evarts A. Graham, St. Louis: My part of the work has been exceedingly small, and Dr. Allen deserves most of the credit for the very ingenious thing which he has shown you this morning. There are a number of things, it seems to me, that are almost of epoch-making importance in connection with this work. Not only is the work of importance from the standpoint that it may relieve these sufferers of mitral stenosis, but more far-reaching than that is the fact that we have in our possession a method that will enable us to study better the whole physiology of the heart and of the mechanism of the heart action and the pathologic physiology of cardiac disease. There are many problems which this method will be able to solve. For instance, a direct experimental attack on just what happens in a mitral regurgitation; a direct experimental attack on what happens in mitral stenosis and some of the vague mysteries revealed by the electrocardiogram spoken of as the T-wave. Electrocardiographers know very little at the present time about the significance of the T-wave. All these things may now be revealed to us, and the clinical application is only one phase. A patient may be clinically relieved of mitral stenosis, but this is only one of the benefits which may result from this work, which I regard as of the highest importance.

Dr. George J. Heuer, Cincinnati: I wish to express my appreciation of this excellent paper. I was interested in this subject several years ago, in 1906, when we tried to produce heart lesions with the instrument we devised, but it was not accurate. I think the wonderful part of this work is the instru-

ment which enables you to see the valve and actually make plain the lesions. It is not at all difficult to go through the ventricle. We have approached the heart through the ventricle, made a lesion of the mitral valve and produced mitral stenosis. But it was done purely by the sense of touch, and we never knew how extensive the lesion was we had made. Therefore, the work was of no particular importance. It was done at the instigation of Dr. Thayer, who was interested in the auscultatory phases of these various lesions.

I am delighted that an instrument has been devised which will enable us to locate accurately a lesion on any of the valves which we desire to attack.

Dr. Edward W. Archibald, Montreal: I do not rise in order to discuss this paper. Indeed, I suppose not many of us are competent to do that. But I do rise as one coming from the country to the north to express my appreciation of this fine piece of work. As a Canadian, I am ready to admit that we are rather proud of ourselves in having got ahead of the rest of the continent in the matter of that great discovery—insulin in diabetes. Canada is now on the map of medical science. I mention insulin merely because, listening to this account of a very new, and probably very valuable method in the surgery and the physiology of the heart, I immediately, for the credit of Canada, cast about in my mind for some achievement of my countrymen to set against it, and insulin was what I thought of; and I trust you will take the comparison as to some extent a measure of the value which, I think, we all place on this brilliant work of Dr. Allen and Dr. Graham.

Dr. Duff S. Allen, St. Louis: Dr. Lilienthal has asked me as to the application of this method and whether it might be desirable to cut the valve. I think it is possible to do that in the human. We have done it repeatedly on cadavers in the operating room. I have devised an instrument of a little different type for the human being. It has a handle; it has a prism, so that you can look through and see what you are doing. It is made in this peculiar shape so that you can push it down in the anterior mediastinum and see what you are doing. I use the same kind of knife and the same kind of lens in it.

I think the mortality in the beginning will be high, because I do not believe we will get these patients to consent to operation unless their condition is pretty far advanced, but it is possible to do that, Mr. President, and I am going to pass this instrument around for inspection. I think we may expect an improvement even if we did the worst thing we could do by cutting a valve, that is, by making a severe regurgitation out of a stenosis, as our slides indicate. We will get greater improvement if we get the normal valve functioning as the result of our cutting.

THREE CASES ILLUSTRATING THE OPEN METHOD OF INTRATHORACIC SURGERY

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I desire to present before this society three cases, each representing a different type, in which the open method was employed. Two of these are examples of the skin sliding operation for the obliteration of large cavities in the chest, one following an extensive and protracted empyema and the other a lung abscess. The third case illustrates the open method of treating malignant tumors of the chest wall invading the thoracic cavity.

REPORT OF CASES

CASE 1.[1]—*Chronic suppurative empyema—skin sliding operation.* Miss F. L., at the age of 4 years, had an attack of measles complicated with pleuropneumonia and appendicitis. After recovery, she was well until about 9 years of age, when she again developed pneumonia, with effusions in the right pleural cavity, which terminated in empyema, and the right pleural cavity was drained. A profuse discharge which continued for five years finally ceased and the sinus closed. Soon after closure, the patient developed fever, which continued for five weeks. The cavity had to be reopened. There was a tendency to closure, but fever returned each time the sinus closed.

When we first saw the patient, May 1, 1915, she had a temperature of 102 F., due to retention of pus. The right pleural cavity was filled with pus.

In February, 1916, a modified Estlander-Schede operation was performed by Dr. Carl Beck. All ribs up to the third in front were removed to the axillary line, and the wound was sutured.

The wound closed, but the cavity did not diminish much in size. Therefore, May 16, 1916, a more extensive operation was performed. It consisted in the removal of the right breast, the larger part of the pectoralis muscle and the third rib. A large skin flap was made and turned inward, the foregoing method being employed. The flap covered a greater part of the raw surface within the pleural cavity and was kept in contact with a good gauze pack (Fig. 1, left). A few days later, the packing was removed, and the flap had grown to the raw surface. From this time on, the chest cavity was treated like an open wound. Adhesive plaster strips were used to produce epidermization from the skin edges. The patient was shown before a medical society (Nov. 17, 1917), and at that time the cavity was practically covered with regenerated skin.

In presenting this case, I desire to show the final result (Fig. 1, right), which demonstrates that not only has the cavity, which was so very large at first, been reduced to about one fourth its size; but also the lung has expanded.

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1. This case was reported in detail in the Surgical Clinics in February, 1912. It is presented here, six years later, in order that the final result may be reported and a brief history of the case added.

One can distinctly see the bulging of the lung with each respiration in the median aspect of the cavity. We can also see the excursion of the diaphragm, and we can feel and see the pulsation of the heart. The cavity is entirely dry and has been so for nearly six years. There are no ulcerations of the skin at present, but they are liable to recur as they have in the past because the newly formed skin is not so resistant as normal skin. There have been no skin

Fig. 1 (Case 1).—Left: Skin sliding operation for chronic empyema. Right: Final results, six years after operation. The cavity is dry and covered with skin, without a skin graft.

Fig. 2.—Final result of resection of anterior chest wall.

grafts employed in this case to cover the large granulating area, but the entire covering has been accomplished by the adhesive plaster method, described several years ago.[2]

2. Beck, E. G.: Adhesive Plaster Method for the Rapid Regeneration of Skin Over Granulating Wounds, Ann. Surg. **69**:291 (March) 1919.

This patient, who has now grown to young womanhood, has very little deformity of the spine because the posterior segment of the ribs, as shown in the stereoroentgenogram (Fig. 2) has been reinforced by growth of bone in the intercostal spaces. Nature has in this way tried to restore the contour of the normal chest. The patient can raise her arm perfectly and perform all of her work with the right arm just as well as with the other.

CASE 2.—*Chronic lung abscess—skin sliding operation.* A boy, now 14 years old, whom I saw first when he was 9½, came to me with a discharging sinus in the chest, for which a rubber tube had been inserted in the back near the middle of the vertebral border of the left scapula. He was then in poor physical condition not only on account of undernourishment, but also from the constant drain of pus and recurrent fever.

The previous history disclosed that, at the age of 5, he had pneumonia, which was followed by an accumulation of pus in the chest. Whether this was

Fig. 3 (Case 2).—Left: Chronic discharging sinus with lung abscess draining five years (1913-1918). Right: Second operation, 1918, showing drain.

a lung abscess or an empyema, I could not ascertain. The parents, who were illiterate, knew only that the child was operated on, a rib being resected. The drainage was in an unusual place, namely, high in the back about 2 inches (5 cm.) from the spinous processes (Fig. 3, left).

The roentgenogram disclosed an abscess cavity in dense walls, occupying the lower one half of the left side of the chest, the pus gravitating down to the diaphragm. The apex was free and the right lung in good condition. March 1, 1920, I decided to make a counter drain, by an incision along the tenth rib, removing 1 inch of the rib and putting in a through rubber tube with gauze, as shown in Figure 3, right. The suppuration, however, persisted, and there was no tendency to healing. I waited ten months, until December, 1920, for healing, and then decided on a skin sliding operation, which is well illustrated in Figure 4. In the stereoscopic picture, the depth of the cavity is quite plainly visible. The flap adhered perfectly to the upper surface of the cavity, forty-

Fig. 4 (Case 2).—Third operation, 1919: skin sliding.

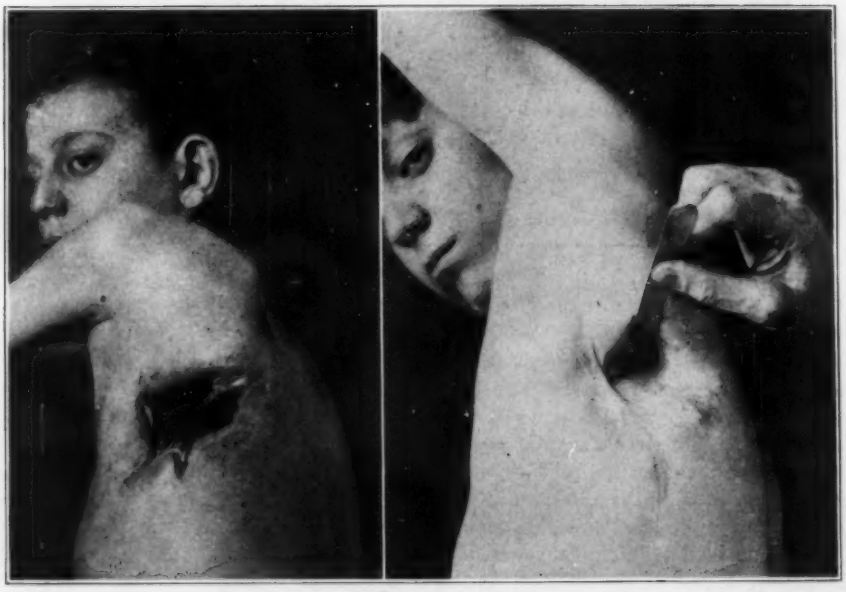

Fig. 5 (Case 2).—Left: Cavity gradually filling in and skin gradually regenerating. Right: Final result, 1923: a funnel-like recess entirely covered with new formed skin, without skin graft.

eight hours after operation. A large area of granulating surface (Fig. 5, left) was left to gradual skin regeneration with the help of the adhesive plaster, as in Case 1. Regeneration of the skin took place gradually and beautifully, so that within three months the entire recess was converted into a skin covered funnel. Now three years after, in which time there has been no recurrence of suppuration, there exists nothing but a clean depression, and practically no deformity (Fig. 5, right). The patient's general health is perfect. He has been going to school, and working for me in the summer.

CASE 3.—*Chondrosarcoma of the chest wall involving the pleural cavity; removal of tumor, wound left open.*—J. M. O., aged 55, seven years ago received an injury in the upper part of the right chest, through an automobile accident.

Fig. 6 (Case 2).—Osteochondrosarcoma. The tumor projects 3 inches (7.5 cm.) above the chest wall.

Subsequently, a tumor grew in this region, which was diagnosed at that time as chondroma. It grew to the size of a large grapefruit and was considered nonmalignant. An attempt was made by a surgeon in Montana to remove it, but the attempt was unsuccessful because the tumor reached deeply, about 4 or 5 inches (10 or 12.5 cm.) into the chest cavity. After this operation, the tumor grew more rapidly, until the symptoms became threatening; and the patient was referred to me for consultation, in April, 1923.

A distinct enlargement in the right chest could be seen before the clothing was removed. The tumor bulged out about 3 inches (7.5 cm.) above the level of the chest wall, involving the entire area of the right upper quadrant of the chest (Fig. 6). There was dyspnea due to displacement of the trachea. The patient was somewhat cyanotic, but had no fever, and he was able to walk.

Figure 9 demonstrates that the tumor involved the upper part of the sternum and the clavicle (the first, second and third ribs), and filled the entire upper part of the right chest cavity. The tumor was hard for the most part, but was soft in some areas. The location of the tumor appeared to make it a hopeless case and too great a risk for extensive operation. Nevertheless, an attempt was made at least to remove the overlying tissues and expose the tumor to proper irradiation. This method has been described.[3]

April 23, 1923, under general anesthesia, I resected the clavicle to the upper portion of the sternum for about 2 inches (5 cm.). Then the tumor, in which was embedded the first, second and third ribs, was enucleated, as well as the pectoralis muscle. It was feasible to remove practically the entire tumor, which weighed about 3 pounds (1,360 gm.) (Fig. 7). The wound, which measured

Fig. 7 (Case 2).—Removal of tumor mass, open method, without skin flap.

6 inches (15 cm.) in diameter, was left entirely open. Its depth was that of the upper chest cavity. There was no excessive bleeding, and the cavity was packed. Three days later, the packing was removed and the wound was treated with petrolatum, gauze and aluminum acetate packs.

On the day after the operation, eight radium needles of 12.5 mg. each were inserted along the border lines of the growth, and 100 mg. (in capsules) was placed in the various recesses of the wound. The radium was left in seven hours altogether, a total of 1,403 mg. hours without screening. June 14, this was repeated with 1,147 mg. hours. This was supplemented by a series of deep therapy with 200,000 volts, without much screening.

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3. Beck, E. G.: Intentional Removal of Skin and Other Tissues Overlying Deep-Seated Inoperable Cancer; a Necessity for Effective Treatment with X-Ray or Radium, Surg., Gynec. & Obst. **29**:325-333 (Oct.) 1919.

Fig. 8 (Case 2).—Wound retracted to one-half its size, four weeks after operation; radium being applied.

Fig. 9.—Size and location of tumor before operation. In this figure and Figure 10 the roentgenograms are reversed.

Stereoroentgenograms taken at this time, June 14, 1923 (Fig. 10) show that the upper right portion of the chest is now perfectly free from any growth. The wound has a healthy red granulation. The lung has reexpanded into the upper part of the chest cavity. With the exception of a slight toxemia from the radium and the roentgen ray, the patient has felt well, has had no complications or infection and has been getting stronger from day to day. He is able to be up, and the wound has now contracted to about half its size (Fig. 8).

The microscopic examination showed that the growth was an osteochondrosarcoma with myxomatous degeneration. It is too early to state that there will be no recurrence; but the examination of the lung and the other parts of the body has thus far shown no metastasis. The final result, therefore, is reserved for future publication.

This method of treating malignant growths is not confined to chest cases alone but to growths in other parts of the body. It is practically a transforming of deep seated tumors into superficial ones, preparatory to radiotherapy.

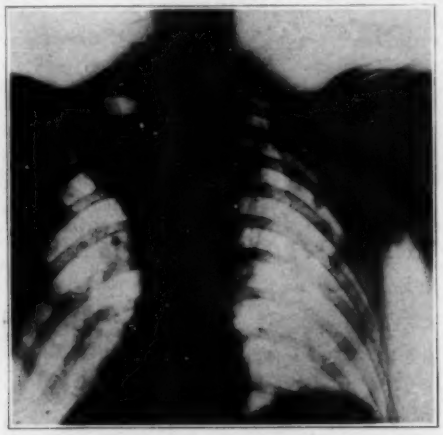

Fig. 10.—Total absence of any tumor mass four weeks later.

It is based on the following factors:

We have established the fact and have come to the conclusion that one of the reasons the deep seated carcinoma is resistant to radiotherapy is the difficulty of delivering a sufficient quantity of rays into the seat of the disease without undue injury to the rest of the body.

I have attempted to solve the problem by converting a deep-seated carcinoma into a superficial one.

Such surgical procedures must of necessity often be very extensive, and therefore connected with some risk. A half way procedure is of no avail in such cases. It was a surprise to us, however, to find that the immediate mortality was not so large as one would expect. It is not necessary to describe the technic, because this varies in each case. If

the principle appeals to the trained surgeon, he will be able to devise his own plan in each case.

We remove the skin and fat and the muscles and as much of the tumor as is safe or possible. This sometimes leaves a perfectly clean field and no visible remnants of the growth. At other times, it is possible to remove only part of the growth because it is attached to or imbedded in vital organs. No attempt is made to diminish the size of the wound by sutures. The wound is left open for subsequent applications of either roentgen rays or radium, as the case may be. This procedure establishes a condition favorable for treatment and similar to that in the case of superficial growths, and we may therefore expect similar results. Allowing this large area to remain widely open, we may now apply the rays, either with the roentgen rays or by planting radium directly in the diseased area. It is now unnecessary to do any material screening, especially when there are large remnants of the diseased tissue left. We have by this procedure eliminated the danger of skin burns and may with safety place radium in direct contact with the tissues which we wish to destroy. Screening becomes necessary only when we have large blood vessels, vital organs or nerves in close proximity to the open wound. The dosage of radiation employed may now be reduced to one tenth of the quantity which would have been required if the application were made through the skin, for the reasons already mentioned.

This method of combined treatment; namely, the removal of overlying tissue and the direct application of the radio-active substances has now been carried out in a variety of cases, sufficient in number to permit of favorable conclusions.

REMARKS ON THE SO-CALLED MEDIASTINAL SEPTUM OF THE DOG, IN RELATION TO THE PNEUMOTHORAX PROBLEM IN MAN

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It is a remarkable fact that after nearly half a century of animal experimentation, in which the dog has been utilized for the systematic study of the problems of intrathoracic surgery, a question so seemingly elementary as the anatomic unity or duality of the pleural cavities in this species should still remain a subject of discussion and controversy. That this is true is abundantly shown by the current literature and the animated discussions that we have heard today. We gather that a new interest in the comparative anatomy of the pleura, from the thoracic surgeon's point of view, has been roused and that many observations have been brought to light which have added to our knowledge of the subject. On the other hand, a certain number of theories have been advanced, here and abroad, by highly competent and trustworthy investigators, which flatly contradict one another, leaving the unprejudiced observer confused and in need of further elucidation.

To attempt a survey of the conflicting theories about the rôle played by the mediastinum in pneumothorax would be to review the history of thoracic surgery, a thankless task, which is neither opportune nor necessary to the purpose of this discussion. My only purpose is to touch on the more salient points in the comparative anatomy of the mediastinal septum of the dog which have a bearing on the surgical relations of the mediastinum in man. While this would seem to be a narrow phase of the discussion of a large problem, it will more than suffice to show its fundamental importance, as well as the conflict of evidence which has beset the final solution of the question.

In this, as in all matters of controversy, what is most important is to determine what is a fact and what merely appears to be a fact, before proceeding to its interpretation.

That a dog dies quickly after one of the pleurae is opened widely, unless the aeration of the lungs is maintained by artificial aids to respiration or the opening in the chest is closed promptly, must be regarded as an indisputable fact. Why does the dog die? Because both lungs collapse, and the respiratory function of the lungs is interfered with and is finally arrested. This is also admitted to be a demonstrable fact; but the mechanism by which the *bilateral* collapse of the lungs is produced, through the opening of *one* pleura, is subject to several interpretations. One more fact remains, and that is that the

dog is far more susceptible to the fatal effects of open pneumothorax than is man. This difference in the susceptibility of the two species to acute pneumothorax was recognized from the earliest days of experimental surgery; but the contrast between the animal and man was never so apparent as during the World War, when the relatively greater tolerance of the human pleura to acute pneumothorax was demonstrated by the great number of open thoracotomies successfully performed for the relief of lung, heart and other intrathoracic injuries, without the aid of differential apparatus.

In previous papers, I have endeavored to show that the safety of unilateral pneumothorax in man is only relative; but that the effects of a thoracotomy on one side in the dog are far graver than in man appears to have been conclusively demonstrated by the accumulated experiences of the war and by later practice.

The tradition which has prevailed among the laboratory workers in the surgery of the chest, from the days of Glück, Block, Schmid and Biondi (1880-1882), that the susceptibility of the dog to the fatal effects of pneumothorax is due to the existence of a normal intercommunicating foramen (or foramina) has apparently been disproved, so far as a gross, demonstrable and constant anatomic communication between the pleurae is concerned. That deviations from the normal type, in which the septum fails to close, are frequent in the dog and other smaller animals cannot be denied. The extreme tenuity of the septal veil favors accidental rupture in experimental work, and that such ruptures are not an infrequent cause of experimental bilateral pneumothorax must also be admitted; but that the normal mediastinal septum of the dog (a thin, pliable, diaphanous veil) is, in the majority of dogs, imperforate, must also be admitted.

From the purely anatomic point of view, the absence of any recognizable perforations or leaks in the normal septum was definitely settled by the painstaking researches of Cazamian.[1] He, however, admits that the cribriform or sievelike perforations, which were described by Quenu and Longuet in 1896 as existing at the interpleural junction in the deep, keellike or carinoid retrosternal space of the dog, is probably an anomaly of frequent occurrence, since the fenestration of the thin endothelial laminae of serous membranes, when brought in contact, is not unusual, as it is observed quite frequently in the great omentum. Cazamian, however, was not able to demonstrate even a netlike fenestration in the pleurae of the dogs which he dissected. The perforation or fenestration of the mediastinal septum as a normal condition in the dog was probably first noted in connection with surgical experimentation by Block of Copenhagen, in 1881. Many others since

1. Cazamian: Du pneumothorax opératoire, Thèse de Bordeaux, 1902.

have referred to it either as a normal condition or as a frequent anomaly (Denys Hellin, Linné, J. B. Murphy, Anselme Schwartz, O. Bruns, and others); but none of these authorities appear to have investigated the subject by direct personal investigation as Cazamian has done. It is curious that practically all the others—experimental surgeons, physiologists, comparative anatomists and veterinarians—who have written exhaustively on the anatomy of the domestic animals, including the dog, and even those who have written monographs on the dog, refer only to a communication existing between the pleurae, when they do admit its existence, in general or vague terms, without specifying the precise seat of this communication. Duval, himself, though working in the veterinary laboratories of the French Ministry of Agriculture, fails to indicate the anatomic localization of this interpleural communication. He is satisfied to prove its existence by the roentgenographic demonstration of bilateral collapse of the lungs, which follows the injection of air into one pluera. In a rather hurried perusal of such standard authorities on the anatomy of the domestic animals (including the dog) as O. Hagemann, Blanchard, Wiedersheim, Ellenberger and Baum, W. Ellenberger, Disselhorst, Fleischmann, Chauveau and Arloing, I fail to find any description of a definite foramen or communication, even when the existence of such a communication is referred to or admitted by the author.

Apart from Quenu and Longuet's retrosternal cribriform fenestration, I have found only one reference to a specific anatomic localization of the alleged foramen or aperture through which the pleurae intercommunicate, and this is merely a passing reference by de Martel, in the discussion of a paper by Duval and Clerc.[2] He states that "in operating on dogs, a bilateral pneumothorax is always obtained, since the interpleural ligament of Morosow or Morosoff (incorrectly quoted as Morieff) remains permeable in the dog." This so-called interpleural ligament, which was first described by Morosow,[3] is a thin connective tissue band which connects the two pleurae to the aorta, esophagus and diaphragm in the human subject. It has been well studied and described by such anatomists as Testut, Poirier, in France, and H. Heiss and others in Germany. It is important because, owing to its dense and intimate attachments to the pleurae, the esophagus and the aorta in the posterior mediastinum, it will not permit the detachment and displacement of the pleurae without tearing them and creating a pneumothorax. The ligament is peculiar to man and does not figure in the anatomy of the dog. In none of the descriptions of the mediastinum of the dog that

2. Duval, P., and Clerc: Bull. et mém. Soc. de chir. **47**:212, 1921.
3. Morosow: Anatomie de l'esophage, Moscow, 1887.

I have read do I find any statement as to the existence of an intercommunicating opening in this ligament, and, in fact, the ligament is not even represented by an analogous structure in this animal. In man, this ligament is, of course, impermeable; in fact, it offers an additional and firmer support to the pleurae and the septum in the posterior mediastinum, giving it a resistance, support and solidity in man that does not obtain in the dog or other lower animals.

When I began my experimental work on the dog in 1897, for the purpose of determining the value of positive pressure with the Fell-O'Dwyer apparatus, I was deeply impressed by the fatal effect of acute open pneumothorax in the species. I then took it for granted that this great susceptibility was due to the permeability of the septum, which led to bilateral collapse of the lungs. It seemed to me that the extreme tenuity and mobility of the septal veil, and the frequent existence of minute cribriform perforations, described by Quenu, accounted for the greater susceptibility of the dog. I was soon satisfied that no progress could be made by open intrathoracic experimentation in this species without the aid of differential pressure. Because of this conviction, I first worked with the Fell-O'Dwyer apparatus and subsequently with the differential pump, devised with the aid and assistance of Dr. John Smyth.

In an extensive research with Dr. C. W. Allen (1913) on the possibility of reducing the thoracic aorta by plication and suture, performed in several stages, the plus pressure pump was first used, and then replaced by the simpler method of intratracheal insufflation of Meltzer and Auer. In all this work, I have acted on the assumption that the pleural septum of the dog was permeable, and that no elaborate or methodical procedure can be carried out in the open thorax of the dog without the aid of some form of differential pressure. Therefore, I took no special pains to verify the existence of the alleged communicating opening by special dissection.

It was not until last summer, when a friendly letter from Dr. Graham inquired the reasons upon which I had based my belief in the permeability of the pleural septum of the dog, that I was led to undertake a revision of my anatomic knowledge of the canine pleura, by the dissection of several dogs freshly killed in the municipal lethal chamber. These dissections failed to show any normal or grossly recognizable anatomic apertures in the septum, either in the anterior or posterior mediastinum, where it had been claimed they existed. A possible means of communication did appear in the anterior mediastinum in the lower retrosternal or carinoid space, as described by Quenu and Longuet, where the right and left pleurae join to fuse into the thin translucent lamella of the medial septum, but even these were potential

rather than actual perforations in the dogs that I dissected. It was quite possible that, under any sudden increase of intrapleural pressure, these weak spots or the thin septal veil would yield, and air would readily find its way from the positive to the negative side. The pressure of other engagements, which called me abroad, prevented me from going further in my investigation. None the less, even the small number of dissections that I had made satisfied me that, from the point of view of pure anatomy, the septal veil was normally imperforate and that Graham's contention that the pleurae of the dog were separate and independent serous sacs was morphologically correct. But to conclude from the mere fact that the septum is morphologically imperforate that the mediastinal septum in the canine species is anatomically and physiologically analogous to that of man, and that the data obtained from experimentation on the dog apply equally well to man, is quite a different proposition, and, I believe, is not sustained by the anatomic facts. As I now see the mediastinal septum of the dog, there is no need of appealing to any direct, visible communication between the pleurae. The mediastinal septum in this species is only a potential partition which can serve merely as a barrier between the pleural cavities when it is thickened or stiffened by inflammatory changes. In normal conditions, such as obtain in experimentation on laboratory dogs, it is as pliable and yielding as the thinnest gossamer or possibly the thinnest rubber used in the manufacture of toy balloons when fully stretched, only far more fragile. It is so thin, lax and flimsy that it offers practically no resistance to atmospheric pressure and when exposed to the alternating inrush and outflow of air in the violent inspiratory and expiratory movements of the thorax, when the pleurae of the dog are opened widely, it flops and flutters, with a motion, as J. B. Murphy picturesquely expressed it in 1896, "like the flopping of a sail in a lull." But apart from the extreme tenuity and mobility of the septal veil, which allow it to yield to air or fluid pressure sufficiently to encroach on the opposite lung, it tears very readily. The structure of this membrane, which is made up of a thin lamina of loose connective tissue lined on both sides by a layer of endothelial cells, would seem to give it a certain porosity which allows air and fluid to filter through it with ease. While on this particular point I have no experimental proof to offer, the permeability of the septal veil is asserted by several writers, as for instance by French,[4] who says: "But, though the dog has two separate and distinct pleural sacs, they are separated by only a thin, diaphanous mediastinum and, as a *matter of fact,* air apparently readily passes

4. French: Surgical Diseases and Surgery of the Dog, Washington, D. C., 1906.

through this *membrane,* and causes the collapse of the adjoining lung." That this statement is not a mere assumption is well shown in the remarkable experimental evidence of the permeability of the septal veil of the dog, not only to air but also to solutions of different density, which Dr. Snyder of the Mayo Clinic has presented today. This would seem to confirm the old view that the bilateral collapse of the lungs of the dog is affected by the actual penetration of air from one pleura to the other, thereby causing a bilateral pneumothorax, and not necessarily by the mere compression of the lung caused by the yielding and floating septum when this is subjected to a differential intrapleural pressure.

It would be interesting to contrast in detail the anatomic differences that exist between the canine and human pleurae, but the careful anatomic studies of Cazamian, who in 1902 investigated the comparative anatomy of the dog, as a surgeon interested in the problem of pneumothorax, make this labor unnecessary. My observations, limited as they are to comparatively few dissections, confirm his statements in practically every detail. To the extreme tenuity and mobility of the septal veil, we must add the mobility of the heart of the dog, which hangs freely in its pericardial envelop, with no pericardial attachment to the diaphragm or to the chest wall. In man, there is no septal veil stretched between the sternum and the pericardium as in the dog. The broad and firm attachments of the pericardial sac to the diaphragm and to the chest wall also give the mediastinum a solid and resisting support, which is altogether lacking in the dog. The firm attachments of the pericardium to the diaphragm stretch and stiffen with each downward pull of the diaphragm and interpose a resisting barrier to the dislocation or displacement of the septum at the very place where the mediastinal veil of the dog is thinnest and likely to flutter with the slightest variations of intrapleural pressure.

The negative anatomic peculiarities of the dog's mediastinal septum, which is a purely potential partition, likewise influence the physiologic effect of variations in the intrathoracic pressure in open pneumothorax, and are sufficient to account for the greater gravity of unilateral pneumothorax in the dog as compared to man.

This conclusion brings us to the question in controversy as it applies to the human subject. There are at present two diametrically opposed views to be considered. M. Pierre Duval, whose achievements in thoracic surgery command for his views and statements the most respectful consideration, contends that the dog is not the proper animal for experimentation on the effects of unilateral pneumothorax, because, in the canine species, the pleurae intercommunicate; and that the conclusions based upon a one-sided thoracotomy in this animal are fallacious, as this procedure leads, almost invariably, to a bilateral

pneumothorax with a fatal collapse of both lungs. He reproduces roentgenograms of dogs that have undergone thoracotomy, to demonstrate the collapse of both lungs when air is admitted into one pleura. He prefers the calf for experimentation, as in the bovine species the pleurae are separate and independent cavities. He contends that in man and in the lower animals in which the pleurae are separated by a well defined and impermeable partition, the interference with the respiration by the collapse of the lung is limited to the side operated on and is therefore well tolerated regardless of the size of the opening made in the chest, and he supports his argument with his clinical experience and that of his co-workers in France. He is convinced that the more complete the collapse of the lung, the better the pneumothorax is tolerated, and the safer it is for the patient. He contends that the asphyxial phenomena observed in the dog after an open pleurotomy confined to one side have led to erroneous interpretations which have exaggerated the dangers of unilateral pneumothorax in man. It is his belief that the misapplication of the findings in canine experimentation, to the conditions which prevail in human thoracic surgery is largely responsible for the invention of the several methods of differential pressure which are necessary in the dog, but are superfluous and cumbersome in man when thoracotomy is performed on one side only.

On the other hand, Dr. Graham contends, with his characteristic vigor and ability, that there is no demonstrable communication between the pleurae of the dog, and that the pleural cavities of the dog are anatomically as separate and distinct as they are in the human subject; but that the mediastinal partition existing in man, as in the dog and lower animals with separate pleurae, is a negligible factor in pneumothorax. The mediastinal septum in man and in the dog is so mobile that any alteration in the pressure on one side is accompanied by an alteration in pressure on the other side, to almost the same extent. He admits that, in the case of great alteration of intrapleural pressure, the agreement between the pressure of the two sides becomes less close, as a result, doubtless, of the fact that, as the mediastinal pleura becomes stretched, its resistance becomes greater. The lungs, in the presence of a unilateral pneumothorax, act as a unit, each lung undergoing almost the same degree of compression, varying with the degree of pressure brought to bear on the lung by the inrush of air through the pleural opening. There is no such thing as a collapse of one lung with active function of the lung on the other side in unilateral pneumothorax. Dr. Graham denies that when a unilateral pneumothorax is created in the chest and cardiorespiratory disturbances occur, these disturbances are not caused by the mere collapse of the lung on the open side but by an encroachment on the total bilateral pulmonary area. The mediastinal partition offers no resistance to the air admitted

through the aperture made in the thorax. The effects of pneumothorax, whether unilateral or bilateral, are dependent on the reduction in the total vital respiratory capacity of the individual. The difference between individuals in their tolerance or intolerance of pneumothorax is dependent on their vital respiratory capacity. In open pneumothorax, the encroachment on the vital capacity of the lungs is determined largely by the size of the opening in the thorax; thus it is possible to estimate the danger of asphyxia by the size of the opening. "Owing to the negligible resistance offered by the mediastinum, it makes very little difference whether there is a unilateral or a bilateral open pneumothorax, provided that the combined areas of the openings in the bilateral case do not exceed the area of the unilateral opening."

From this point of view, the greater susceptibility of the dog to the fatal effects of unilateral pneumothorax would appear to be due to a smaller vital capacity in this animal as compared with man; and the variable degrees of tolerance to open pneumothorax which are exhibited by different individuals of the same species, whether human or canine, would be accounted for by the variations in the normal vital respiratory capacity of the subjects of pleurotomy. "Thus, young athletic individuals, with large vital capacities, can withstand much larger openings than those whose vital capacities are low. The rabbit cannot withstand a pleural opening so large as that of a dog, chiefly because, since it is a smaller animal, its vital capacity is much less than that of a dog."

Dr. Graham's views, which are now familiar to all students of surgical literature, need not be quoted further except to state that they are admirably fortified with experimental data and other evidences in their support gathered from clinical and other collateral sources. The synoptic statement which I have just presented is merely cited to show that in spite of the great appeal that Dr. Graham's thesis has to my reason and experience, there are apparent contradictions in fact and opinion in his controversy with M. Duval which justify further debate and investigation. Without going further than the anatomic peculiarities of the canine pleura with which I am especially concerned in this discussion, I would conclude that Dr. Graham is right in his estimate of the mediastinum of the dog as a negligible structure, and also in his view that, while the pleurae in this species are anatomically separate, they behave physiologically as one cavity when thoracotomy is performed on one side. But I am not quite sure that the bilateral compression of the lungs that follows a unilateral opening is effected by the simple displacement of the yielding septum or by an actual permeation of air into the opposite pleural cavity through its flimsy structure, as Dr. Snyder's interesting observations, here reported, would suggest.

In neither case can the conclusions of experimentation in the dog, without artificial aids to respiration by differential pressure or otherwise, be applied in their integrity to human thoracic surgery. I have also endeavored to show that the anatomic differences between the mediastinal septum in the dog and in the human subject are so great, in the sense of the superior resistance and solidity of the human mediastinum, that the two cannot be placed in the same category. In the animal, the mediastinal veil is merely a film, a potential partition, which may become a barrier in pathologic conditions. In man, the mediastinal septum is a composite anatomic wall, which is solidly rooted in the chest through the attachments of its pericardial supports to the diaphragm. It may yield, stretch and even flutter under varying conditions of positive atmospheric pressure, but not to such an extent as to become a negligible quantity in estimating the resistance of the interpleural partition in acute open unilateral pneumothorax.[5]

5. In a recent article (Presse méd., No. 68, Aug. 25, 1923, p. 733), M. Pierre Duval, in replying to the criticisms of Dr. Graham, in the same publication (No. 13, Feb. 14, 1923), revises his original contention that the pleurae of the dog intercommunicate, and frankly admits that, contrary to his previously expressed belief, there is no gross anatomic opening that is recognizable in the normal canine septum. This admission, he contends, does not invalidate the fact that *experimentally* the pleurae of the dog should be regarded as a single or common cavity, since injected air, blood and fluids which are opaque to the roentgen rays, readily find their way through the septum, from one pleura to the other, without any apparent or gross breach in the continuity of the septal membrane. Furthermore, the tenuity and fragility of the mediastinal veil of the dog is such that it cannot resist any differential pressure applied to its surfaces. Therefore, the deductions and conclusions drawn from the interpleural experimental surgery of the dog are not applicable to human intrathoracic surgery. I regret that this interesting contribution reached me too late for the experimental and anatomic evidence on which M. Duval has based his conclusions to be incorporated in the text of the preceding discussion, as they are especially interesting in connection with Dr. Snyder's observations.

A RECONSIDERATION OF THE QUESTION OF THE EFFECTS OF AN OPEN PNEUMOTHORAX*

EVARTS A. GRAHAM, M.D.

ST. LOUIS.

One of the most fundamental necessities for the progress of thoracic surgery is a better understanding of the physiology involved. Of the physiologic problems, there is none more important than an accurate knowledge of just what happens when an opening is made in the chest. The effects of open pneumothorax, therefore, should be studied and discussed until as much knowledge as possible has been obtained on this subject. My reason for presenting the matter again is chiefly to encourage a more accurate study of the problem and to dispense with much of the conjecture which exists in the literature.

In 1918, in association with R. D. Bell,[1] I reported the results of experiments both on human cadavers and on animals which seemed to change the existing conceptions of the effects of an open pneumothorax. The most important finding in our experiments was that in a normal thorax, one in which there were no adhesions and no thickening of the mediastinal structures, the mediastinal partition between the two pleural cavities was so flexible that it offered little resistance to changes of pressure. Certain conclusions drawn from the work were: 1. Whenever a change of pressure is made in one pleural cavity, a change in the other occurs to almost the same extent. This conclusion is opposed to the generally accepted ideas, such as are expressed, for example, by Garré,[2] who considered that whenever a free opening is made into one pleural cavity the lung on that side becomes collapsed and functionless. 2. Death in open pneumothorax is usually death from asphyxia. 3. The size of the opening is an important matter, and of particular importance in this connection is the vital capacity. Individuals with high vital capacities can withstand larger pleural openings than can those with low vital capacities. 4. Bilateral open pneumothorax is not fatal if the openings are not too large. 5. An important and serious factor in open pneumothorax is the marked loss of heat which usually accompanies the condition. 6. In large openings, there is also a serious disturbance in the systemic circulation, due probably to an interference with the

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*From the Department of Surgery, Washington University School of Medicine.

1. Graham, E. A., and Bell, R. D.: Open Pneumothorax: Its Relation to the Treatment of Empyema, Am. J. M. Sc. **156**:839 (Dec.) 1918.

2. Garré: Der Pneumothorax, III Congrès de la Soc. internat. de chir. **1**, 1911.

normal return of venous blood to the heart because of altered intrathoracic pressures. 7. A mathematical expression was given by which it was felt that the maximum nonfatal opening of the chest wall which any particular individual could withstand could be prophesied approximately if the value of the vital capacity were known. 8. The presence of adhesions or of thickening of the mediastinal structures materially changes the effects of alterations of pressure in one pleural cavity.

Criticisms of our work have been made by various authors. In general, these criticisms have been of two kinds. In the first place, many writers have centered their attention on only that part of our work which dealt with the mathematical expression given. They have questioned the validity of the whole work because they state they have seen life continue with openings in the chest wall which were larger than the 50 square cm. or the 8 square inches which in our original article was given as the theoretical maximum nonfatal opening in the average adult. In the second place, the popular myth of the presence of a normal communication between the two pleural cavities of a dog has often been quoted as indicating that our experimental conclusions have been erroneous, on the ground that the dog is not a suitable animal on which to carry out experiments in pneumothorax. In our work, most of the experiments were performed on dogs.

It has seemed advisable to reply to these criticisms, not for the purpose of being controversial but because I believe that many lives will be needlessly sacrificed if the fundamental conclusions quoted above are disregarded. For example, Duval [3] has recently severely criticized our work, basing his arguments on the two general lines mentioned above; namely, that the theoretical maximum nonfatal opening which we gave is entirely wrong in principle and that conclusions based on experiments on dogs cannot be applied to the human because of the alleged normal communication between the two pleural cavities of the dog. Not only does he consider the essential conclusion of our work wrong, but he goes so far as to maintain that a unilateral open pneumothorax is not dangerous if the opening be made sufficiently large. He claims that a large opening is less dangerous than a small one, and he cites an experiment on a calf which he claims to support his ideas. He uses a calf because he states that cattle, like rabbits, have thoraces which more nearly resemble that of the human than has the dog. In answering this article of Duval recently, I [4] reported an experiment of my own on a calf, showing clearly that a large unilateral opening was

3. Duval, P.: Les données actuelles de la chirurgie intrathoracique unilatérale en plèvre libre, Presse méd. **30**:409 (May 13) 1922.

4. Graham, E. A.: Principes qui découlent de la chirurgie intrathoracique, Presse méd. **31**:141 (Feb. 14) 1923.

just as fatal in a calf as it is in a dog and as, I am sure, it is in a human. I called attention also to the fact that in my original work the experiments had been conducted not only on dogs but also on rabbits.

As a matter of fact, also, discussion concerned only with the theoretical maximum opening which a normal person can endure deals

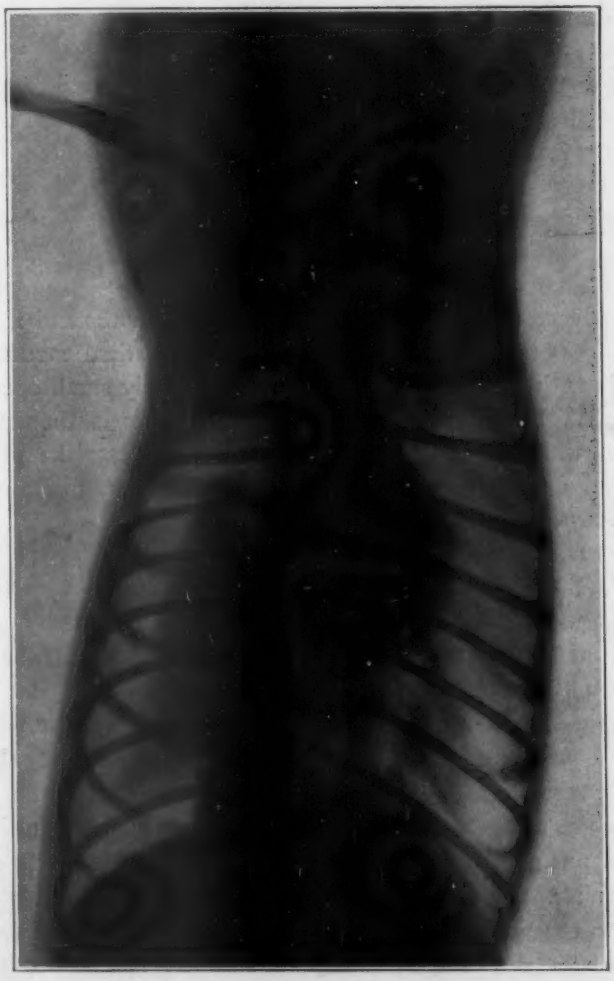

Fig. 1.—Unilateral pneumothorax in a normal living dog. The "collapsed" lung and the deviation of the heart and mediastinal structure are evident. This would be impossible if a communication between the pleural cavities were present. The air was injected into the left pleural cavity.

only with a matter of detail rather than with a principle. The value given in my original paper, calculated from our formula, was, as stated, based on what textbooks of physiology at the time gave as the average

vital capacity (3,500 c.c.). Subsequent work by Peabody and Wentworth [5] has shown that the average vital capacity is higher than this earlier figure, and that in men the average is about 4,800 c.c. In one man, they found a value of 7,180 c.c. Our original value for the maximum nonfatal opening was therefore too small, and in a subsequent article,[6] I corrected it, and showed that the average for a man, based on the figures of Peabody and Wentworth, would be about 67 square cm., or 10.4 square inches. Those, however, who have exceptionally high vital capacities will be able to endure very large openings; as, for example, 101 square cm., or 15.7 square inches, in the man whose vital capacity was 7,180 c.c. But these figures are not to be taken too literally because several factors enter into the calculation, all of which cannot be accurately determined. The formula has always been intended merely to express an approximation. The important point is that the value of the vital capacity of any individual governs to a great extent the size of the opening in the chest which he can withstand if he has no pleural adhesions nor thickening of his mediastinal structures. In individuals with very low vital capacities, relatively small openings will be fatal. As I have pointed out repeatedly, this is the only logical foundation which exists at present upon which rests the principle of avoiding an open drainage during the acute pneumonic stage of an empyema, a period at which the vital capacity is very low. I think this principle is now generally accepted, at least in this country.

The fact that some surgeons claim that they have seen certain individuals who have lived with larger openings than my theoretical values would allow has really not very much to do with the principle at issue, unless they are sure that these individuals had low vital capacity readings and that they had no pleural adhesions or other pathologic conditions that would tend to make the mediastinal partition abnormally rigid. It is curious also that many who criticize the principle make use of measures to combat the respiratory difficulties arising from open pneumothorax which of themselves tend to reduce the size of the opening. Duval, for example, recommends packing gauze compresses into the wound. Moreover, nearly all surgeons, while working with a nonadherent lung, either deliver the lung out of the incision or put their hands and instruments into the incision. All of these measures tend to reduce the size of the opening. Is a hole that is plugged any longer a hole? Or is a hole that is even partially plugged as large as it

5. Peabody, F. W., and Wentworth, J. A.: The Vital Capacity of the Lungs and Its Relation to Dyspnea, Arch. Int. Med. **20**:443 (Sept.) 1917.

6. Graham, E. A.: Importance of the Vital Capacity in Thoracic Surgery, J. A. M. A. **75**:992 (Oct. 9) 1920.

was originally? It would seem unnecessary to call attention to this simple discrepancy in reasoning if it were not for the fact that many of the critics of my work have failed to consider it. It is a significant fact that the war emphasized strongly two points regarding operative work on the chest. One of these was that all open wounds of the chest

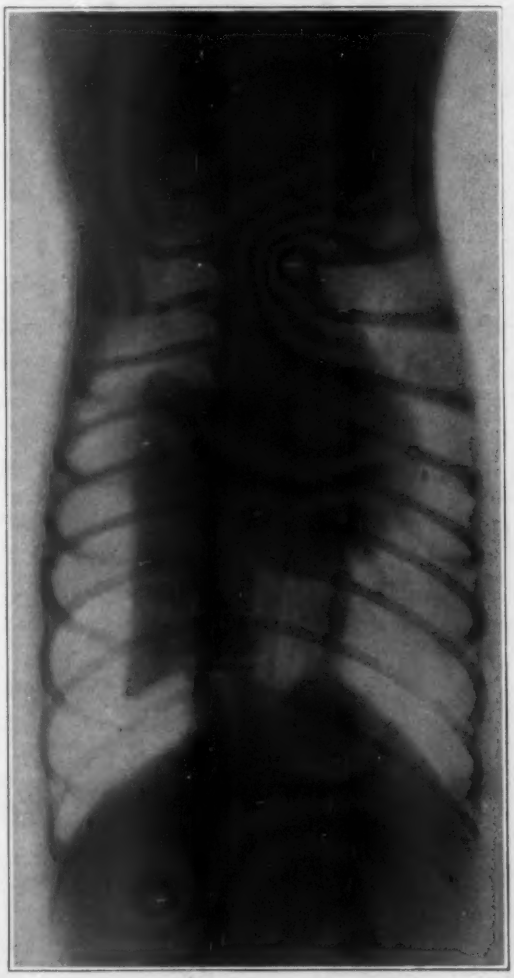

Fig. 2.—Unilateral pneumothorax in another living dog made in the same way as in Figure 1.

should be closed as soon as possible, and the other was that intrathoracic operations should be performed as quickly as possible.

The second chief point of criticism of my work has been based on the idea that the dog is an unsuitable experimental animal for work on pneumothorax because of an alleged communication between the two

pleural cavities. Although, as stated elsewhere, I used rabbits and cats as well as dogs in my earlier work, most of the experimental work was done on dogs. I cannot understand what the basis is for the common belief that in the dog there is a communication between the pleural cavities. I have carefully examined twenty-five dogs to discover the alleged opening, but I have never found it. Not only have I made dissections, but I have also tried injections of both air and fluids into one pleural cavity and attempted to discover whether they were transferred into the other pleural cavity. When the experiments were

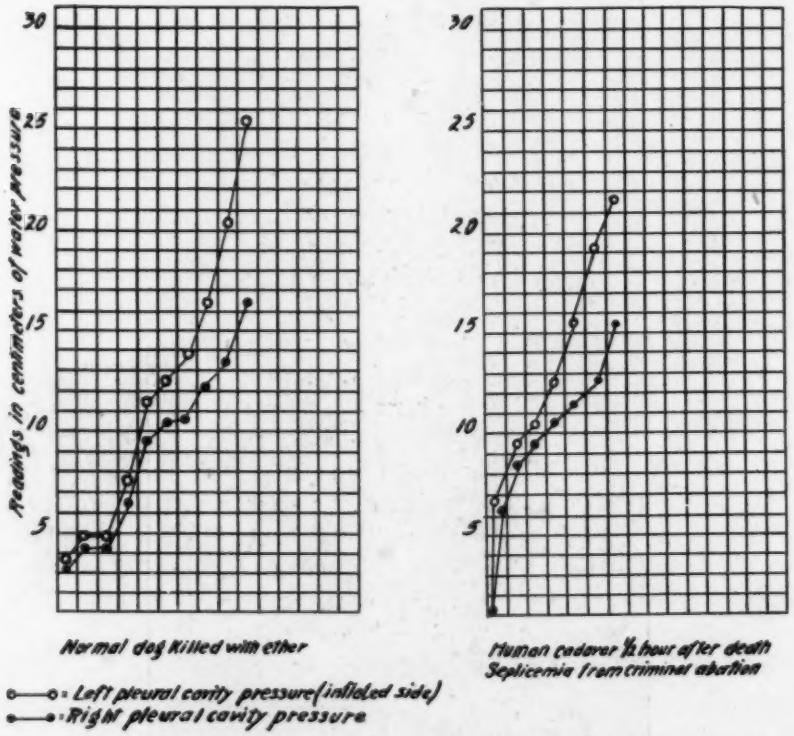

Fig. 3.—The close agreement between the normal dead dog and the normal human cadaver in their response to changed intrapleural pressures induced by the injection of air into one pleural cavity at known pressures is shown. This would indicate that the normal human mediastinum is nearly as flexible as is that of the dog.

properly conducted, with due care to avoid puncturing the mediastinal pleura, I have never seen the transfer from one side to the other. Duval has stated that a unilateral pneumothorax in the dog becomes bilateral. I have not found that to be the case if due care is used. The accompanying roentgenograms show clearly that in the dog a unilateral pneumothorax is possible.

In the dog, there is a septum which lies between the sternum and the pericardium which separates the two pleural cavities anteriorly. This is composed of two layers of pleura with a little fat. In most dogs, it is so thin as to be transparent. It is also very flexible. The same kind of partition is also present in the human thorax. Like that

Fig. 4.—Appearance of chest of dog immediately after injection of 20 per cent. sodium bromid into one pleural cavity. The solution is definitely limited to one side of the chest.

of the dog, the human partition is very thin, but usually not quite so thin. In emaciated subjects, however, I have seen it thin enough to be transparent. In obese subjects, on the other hand, it is likely to contain more fat. In this respect, it resembles the great omentum.

In the human being, although this partition is also very flexible, it is relatively less extensive than in the dog. In our earlier work, we stated that there was a fairly close parallelism between the flexibility of the dog's interpleural partition and that of the human being. In view of the more recent criticism of our work, and therefore of our conclusions, I felt that it would be advisable to repeat some of the experimental work reported in the first article. Accordingly, with the assistance of Dr. Duff S. Allen, I injected air into one pleural cavity of a dog through a trocar, and observed the pressure readings in terms of centimeters of water in both pleural cavities. I also performed the same type of experiment in an adult cadaver immediately after death, while the body was still warm. The accompanying chart gives the results. It will be observed that, although the interpleural partition in the human being is slightly less flexible in general than that of the dog, there is a fairly close agreement between the two, and the results are practically the same as those published in my first article. In this connection, it should be emphasized that, in conducting experiments of this sort on the human cadaver, certain conditions must be observed: 1. The cadaver must have a normal thorax, as determined later by necropsy; i.e. there must be no pleural adhesions, no pleural effusions, no abnormal thickening of the mediastinal structures and no consolidation of the lungs. 2. The body must be obtained almost immediately after death. If chilling or rigor mortis has occurred, the results will be very different, as I have observed. 3. The same care in not puncturing the mediastinal pleura, the diaphragm, or the lung must be observed as in the case of the dog.

Two or three months ago, Dr. Hedblom was kind enough to write me that Dr. Snyder had found that when sodium bromid is injected experimentally into one pleural cavity of a dog, the roentgen ray reveals its presence in both pleural cavities, thus indicating that a communication exists between the two pleural cavities. It occurred to us that this finding did not necessarily indicate an opening in the ordinary sense of the word, but that perhaps it was merely an expression of the well-known phenomenon of the dialysis of a salt through a membrane. Accordingly, we injected a solution of 20 per cent. sodium bromid into one pleural cavity and took a roentgenogram. The salt solution was definitely on one side. After fifteen minutes, another roentgenogram showed that it was now on both sides. The result was about what we expected, if the process was a dialysis; but in order to be more certain, we carried out an ordinary dialysis experiment, using as the membrane the septum between the sternum and the pericardium. The experiment was conducted thus:

A piece of the septum was tied over one end of a glass tube of a diameter of 1 cm. A little distilled water was then placed in the tube, and the lower end was immersed in a beaker containing 20 per cent. sodium bromid, until

the two fluid levels were even. At various intervals, a few drops of the fluid in the tube was taken out with a pipet and added to test tubes containing a little distilled water to which silver nitrate had been added. The silver nitrate reacted with the sodium bromid to give a precipitate of silver bromid which was easily visible. At the end of five minutes, there was a heavy precipitate of silver bromid. The membrane was then tested for an opening by blowing on the tube, but no opening was found.

The experiment was, therefore, merely another demonstration of the well-known phenomenon of dialysis. In an identical manner, the same septum from an adult human thorax, obtained at necropsy, was used in an experiment, and strictly comparable results were obtained except for the difference that it required about ten minutes of dialysis to obtain the same degree of heavy precipitate of silver bromid. This difference after all is not great and has no particular bearing on the important question: Are the dog and the human comparable as regards reactions to changes of pressure in one pleural cavity?

Another objection to our theory that has been raised by some is that, since roentgenograms of patients with a unilateral pneumothorax show the lung on the affected side to be more dense in appearance than the other lung, obviously there must be a great inequality of pressures in the two pleural cavities. Another factor, however, enters into this phenomenon, which may serve to explain this apparent discrepancy. When enough air is introduced into a pleural cavity, the lung is pushed away from the chest wall, so that the adhesive force with which it is normally held in contact with the parietal pleura disappears. The elastic fibers of the lung are then allowed to play on the lung to a degree which is not possible in the other lung. As a result, the lung on the affected side is actually compressed more than is the other one, and therefore it appears more dense. This fact is not entirely dependent on the actual pressure exerted on the lung by the air introduced into the pleural cavity. It is, therefore, entirely possible to have a close agreement between the two pleural pressures and yet have one lung more dense than the other. The determinations of the specific gravities of the two lungs under the conditions of the experiment are very difficult, and more recent observations have led us to believe that our former observations on this point were perhaps erroneous.

Another consideration of the effects of pneumothorax concerns the question of the modification of blood flow through the lung induced by a sudden rise in the intrapleural pressure. The question of the relation of the respiration to the circulation has long interested physiologists. It seems beyond the province of this paper to discuss these points in detail. They may be found fully presented in any standard textbook of physiology. Yates [7] and his associates have recently emphasized the

7. Yates, J. L.: Effects of Acute and Chronic Pneumothorax (A Preliminary Report), Am. J. M. Sc. **165**:1 (Jan.) 1923.

importance of considering the effects on the pulmonary circulation exerted by a pneumothorax, and they have called attention to the greater amount of blood in the lungs in cases of pneumothorax. This is an important point and deserves more study. It has long been known that a rise of blood pressure occurs in association with asphyxia. It is,

Fig. 5.—The chest of the dog shown in Figure 4, fifteen minutes later. The sodium bromid has dialyzed through the mediastinal structures into the other side.

therefore, not surprising that in cases of open pneumothorax a compensatory increase of blood pressure occurs. It would seem also that, of necessity, this increase in blood pressure would be reflected in the presence of a greater amount of blood in the lungs. In our original

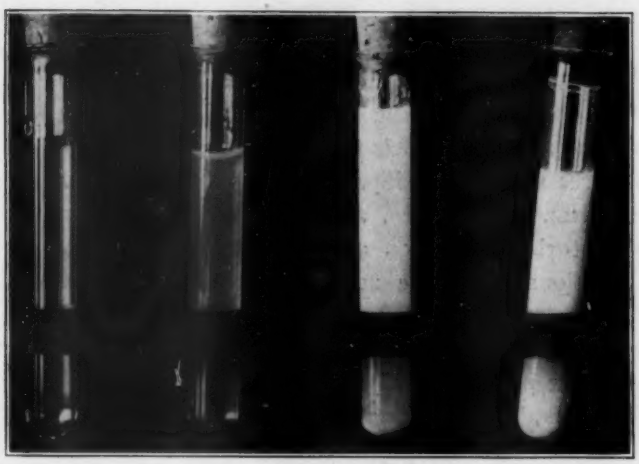

Fig. 6.—Experiment to show the dialysis of sodium bromid through the interpleural partition of a normal dog. The second, third and fourth tubes represent the amount of dialysis of the salt in one, two and three minutes, respectively.

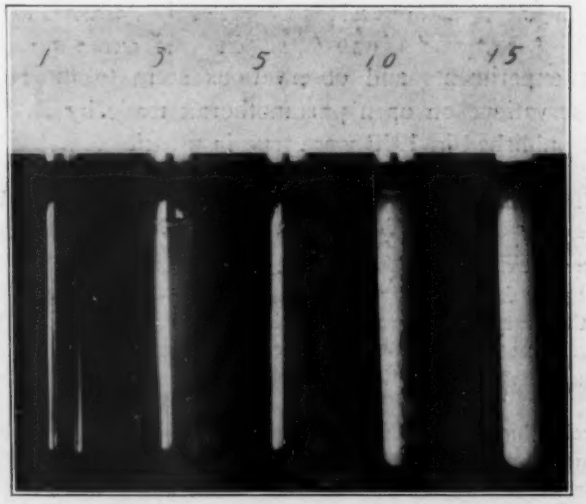

Fig. 7.—Experiment similar to that shown in Figure 6, the interpleural partition from a human subject being employed. The figures represent the time in minutes. Dialysis is a little slower through the human partition than through that of the dog, but it occurs readily. An explanation of the experiment is given in the text.

article, we called attention to the rise of blood pressure when asphyxia occurs from an open pneumothorax; and we also quoted Sauerbruch as having shown an increase in the venous pressure of the femoral vein, which he attributed to a diminished aspirating action on the large thoracic veins because of disturbed thoracic pressures. It seems to me that these effects are all sequels to the disturbance of respiration and to the altered pressure relationships in the thorax. The matters of fundamental importance, therefore, are the questions as to how a pneumothorax disturbs respiration and how it alters the normal thoracic pressure relationships. The actual cause of death, as well as the dyspnea, in open pneumothorax seems unquestionably to be due to asphyxia. In a recent article attacking Duval's theories, Dautrebande and Spehl [8] have produced definite evidence to show that death in open pneumothorax is due to anoxemia.

It has seemed to me that no theory of the mechanics of pneumothorax so readily explains all the facts as the one based on our experimental results. For a more complete discussion of it, reference should be made to our original article. Those who have taken issue with our findings have so far failed to offer in substitution any theory which agrees so readily with the clinical facts. Moreover, I desire to call attention to the articles of some whose findings confirm ours. I refer to Stivelman, Hennell and Golembe,[9] to S. Simon [10] and to C. H. Lenhart.[11]

CONCLUSION

Further experiments and observations seem to indicate that the original observations on open pneumothorax made by R. D. Bell and myself and published in 1918 were true in principle.

DISCUSSION ON THE PAPERS OF DRS. BECK, MATAS AND GRAHAM

Dr. Willy Meyer, New York: The question of anatomic details in the pleural cavity of dogs belongs to the domain of the comparative anatomist. If they say there are cribriform communications between the right and the left side, we must accept their statements as correct. But so far as practical operative experience goes, such findings have, it seems to me, no special importance.

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8. Dautrebande and Spehl: Les Causes de la dyspnée et de la mort dans le pneumothorax ouvert, Bull. de l'Acad. roy. de méd. de belg., November, 1922.

9. Stivelman, B. P.; Hennell, Herman, and Golembe, Harry: Clinical Significance of Altered Intrathoracic Equilibrium in Pneumothorax, J. A. M. A. **78**:1450 (May 13) 1922.

10. Simon, S.: Effect of Artificial Pneumothorax on Collateral Lung, Am. Rev. Tuberc. **5**:620 (Oct.) 1921.

11. Lenhart, C. H.: Open Pneumothorax; an Experimental Study of the Functional Pathology of Sucking Chest Wounds, Arch. Surg. **1**:336 (Sept.) 1920.

In the four years of experimental surgery on dogs at the Rockefeller Institute (I am referring only to total lobectomies, of which we had twenty-six cases with twenty-two recoveries) we noticed that, after the animals had gone through the immediate effects of the operation, they recovered quickly, jumped around and barked, two or three days later, as if nothing had happened. I must say, if there existed a physiologic direct communication between the two pleural cavities, we ought to have had collapse also of the opposite lung, at least to some extent. But this, I believe, never happened. A dog afflicted with bilateral collapse should have shown different symptoms in life from those we observed. The cribriform communications mentioned, therefore, do not seem to amount to anything "in praxis," certainly not to much.

What I learned in the earliest years of my practice was that the anatomy of the cat resembles that of the human being more than does that of the dog. Animal experimentation is carried out mostly on dogs today. Should it be shown that these small communications really mean much in drawing useful results from our experimental work, it might be wiser to operate on cats, at least for research in thoracic surgery.

I have followed Dr. Graham's work with intense interest and admiration. In the midst of war duties he published, with Dr. Bell, a splendid paper on acute operative pulmonary collapse. As I understood it, Dr. Graham, in his early work in the midst of the war, could make his observations only on patients in whom the pneumothorax occurred in connection with early operation for acute empyema. We pointed out in our discussions on this subject before the Association in former years that such collapse was different from that seen in the so-called virgin pleural cavity; that is, one in which there are no adhesions whatever and all the tissues are normal and not infiltrated. Apparently, Dr. Graham wanted to find out how large an opening could be safely made in the chest wall in intrathoracic operations without having to fear the deleterious consequences of a total collapse of the lung; and he showed us how far we can go with safety.

I would again emphasize the well-known point that about 50 per cent. of the patients undergo operations within one pleural cavity without any detriment, just as they do in other parts of the body. The surgeon, therefore, in some instances could proceed without fear and without difficulty on ordinary operative lines, if he knew beforehand who are the fortunate fifty out of the hundred who can withstand acute collapse of a lung. The limit of safety may easily be overstepped.

For these reasons, I would again emphasize that it is advisable, before starting intrathoracic work, to have on hand a differential pressure apparatus, on the working of which we can rely, so that the danger to the patient in consequence of a possible operative collapse of the lung can be totally eliminated. The surgeon's work in the chest must be as safe as that within the abdomen, or the cranial cavity. Fortunately, it can be made so today.

Dr. Carl A. Hedblom, Rochester, Minn.: What we are all seeking is the truth. We are on common ground in that.

Dr. Snyder at my suggestion undertook an experimental study of intrapleural tension as the basis for a thesis, and this afternoon he will present his evidence. It seems to me only fair that we should suspend judgment in this until we have heard him. After Dr. Snyder has read his paper, I should like to say something as to my attitude on the subject.

Dr. George J. Heuer, Cincinnati: With regard to the openings in the pleura and in reference to the remarks of Dr. Graham and Dr. Matas, I thought the whole question was settled many years ago by William Snow of the University of Wisconsin, who clearly proved that there were no stomas in the pleura or peritoneum.

This question resolves itself into the point whether there are or are not stomas in endothelial membranes. By some silver impregnation staining methods Snow clearly demonstrated this, and his work, so far as I know, has not been refuted. There are no stomas in endothelial membranes. He showed there was no tension on the membranes, and that openings could be produced between the endothelial cells—the stomas which had been described by previous observers. I do not think the experiment of putting the endothelial membrane of a dog under pressure to determine the presence of stomas has been tried. That might be a valuable contribution to the subject. However, it is clearly established that there is no opening between the two pleural cavities of the dog.

Dr. Nathan W. Green, New York: The remarks of Drs. Heuer and Matas have an important bearing on the vivisection controversy. The argument is frequently advanced by antivivisections, when we are experimenting on a dog, that some noted surgeon has said the experiment was not applicable in any way to the human being because the anatomy in the human and in the dog is so different. It makes it important to have this point settled. Dr. Meyer almost took the words out of my mouth when he said that it should be referred to the professor of comparative anatomy.

I want to cite a case in connection with my own experimental work. When I was working with one of my colleagues in 1906-1908, it was our impression that there was a communication between one pleura and the other in some of our dogs. We took this point up with Dr. George S. Huntington, Professor of anatomy in the College of Physicians and Surgeons in New York, and it is my recollection that he said absolutely and finally there was no communication between one pleura and the other in the dog, although we had seen what we thought were cribriform openings in the septum just anterior to the heart. I am convinced that the openings we observed were all artefacts, the result of increased pressure on one side over the other or of rough handling.

Dr. John L. Yates, Milwaukee: From a practical standpoint, the issue Dr. Graham raised first, that of the vital capacity of the lungs, is fundamental. There are few if any intrathoracic abnormalities in which the vital capacity would fail to indicate to some degree the actual and reserve power present. Vital capacity is, however, not the best single index of what may or may not be done safely.

In 1918, we attempted to produce sufficient compression of the lung to control hemorrhage from war wounds by artificial hydrothorax. Experiments on dogs confirmed Dr. Graham's observation; unilateral hydrothorax cannot be obtained. We attempted, by using stains, to find the connection between the two sides of the chest, and failed. We also tried to produce unilateral pneumothorax to obtain compression as used by Bastianelli. We could obtain just such evidence of unilateral pneumothorax as is shown by Dr. Graham here today, but only for short periods. Later, according to our observations, the pneumothorax became bilateral, just as the hydrothorax had, except for a longer time element. We noted, during thoracotomies on dogs, that there was a constant emphysema of the mediastinum, and possibly this indicates the manner of communication between the two sides of the chest.

Let us consider next the influence of intrapleural pressures on vital capacity. Most decidedly this is not a question solved by however many observations of whatever nature on all sorts and conditions of dead animals. The reasons are definite and comprehensible. Vital capacity is determined by pulmonary inflation, which in turn depends on four factors: (1) intrapleural negative pressure; (2) intratracheal pressure; (3) pulmonary elasticity, and (4) the vascular tension in the pulmonary circulation. The last is of signal importance in any consideration of the effects of varied intrapleural pressures.

Dr. Heuer in his work in studying the compensatory changes occurring after lobectomy has confirmed what has been observed repeatedly: shunting the pulmonary circulation from one part of a lung to another part having normal elasticity produces instant emphysema in the hyperemic portion. This is a compensatory process to preserve the vital capacity necessary for life and depends on the ability of the right heart to deliver and to maintain the necessary pressure in the pulmonary circulation.

Let us discuss for a minute what occurs in living animals. If air is introduced into one side of the dog's chest and pressure is exerted, an equal pressure develops at once in the opposite side, as Dr. Graham has shown us today. On the other hand, if we use monkeys and introduce air into one side of the chest, there is not a corresponding rise in the pressure on the other side. As we demonstrated two years ago, a healthy monkey will tolerate a unilateral positive pressure five or more times as great as the normal negative pressure without showing change in the amount of contralateral intrapleural pressure.

As to the difference between the mediastinum of a dog and that of a monkey the latter is more nearly like that of man. Dr. Miller has proved that the mediastinum of monkey and of man are of the thick variety and that of the dog is of the thin variety. Hence, the difference is anatomic. You can establish and maintain unilateral pneumothorax in monkey and man and you cannot in dogs. Experimental observations are not comparable and are of little value if this difference is not recognized. Moreover, observations on cadavers, fresh or frozen, are of no value in relation to problems in the living, since the two chief factors, vital capacity and competence of the pulmonary circulation, are eliminated.

Ability to withstand unilateral or even bilateral pneumothorax depends on the capacity of the circulation to deliver enough blood to maintain a viable degree of pulmonary inflation, or vital capacity. If pneumothorax is created gradually, the circulation has a better opportunity for adaptation. Granting an adequate supply of blood in circulation, the functional capacity of the myocardium is the chief factor in effecting compensation. Heart muscle, in the last analysis, is the deciding factor, and therefore needs to be considered and protected. The rapidity of production of pneumothorax is an important factor, because it determines the size of the extra burden placed on the heart as well as the suddenness of the demand for extra effort.

In an experiment performed on a German soldier, we tried to answer the question as to whether an individual could stand complete immediate destruction of one whole side of the chest. This man was in good shape. During an operation to repair a wound in a lung, it was possible to get the hand around the pulmonary vessels. One observer watched the blood pressure in one arm, another noted the pulse rate on the opposite side. They could not tell whether or when the entire pulmonary circulation to one side was suddenly interrupted. So far as testing circulatory adaptability was concerned, this was more severe than

suddenly removing a half of the chest wall because pulmonary collapse squeezes a considerable volume of blood into the general circulation. On the contrary, soldiers in shock could barely tolerate very small openings until the hemothorax was relieved and pulmonary inflation was reestablished by positive pressure.

We must recognize that observations of value in treating patients suffering from the intrathoracic disorders must be made on living animals of such similar structure as to have comparable physiologic mechanisms. Facts are needed badly. One fact is established; the functions of respiration and circulation cannot be divorced. Observations neglecting this basic truth are not applicable to problems affecting the lung.

Dr. Emil G. Beck, Chicago: I wish to present two cases illustrating the chronic type of empyema. You have all seen a great many of them before. They are most difficult to deal with because the patients have been operated on once or twice without result, and then came the question of obliterating these large cavities by surgery. These two represent neglected cases which would not yield to any treatment. A little boy, who came to me about four years ago, at the age of four had empyema or lung abscess, which was drained in an unusual place, near the spine in the region of the scapula. It discharged pus for four years. He was run down, had fever constantly and was in poor health. I diagnosed the condition by a roentgenogram, which showed there was an abscess in the chest, and I made a counterdrain at the original opening. But this did not help; so I resorted to a skin-sliding operation, removing three ribs. The lung was exposed, and a large area of granulation tissue left uncovered.

It is necessary to make skin slides in these cases. If you fold the skin high into the apex, new skin will grow from the edges of the flap until it covers the entire cavity. The lower part was not covered with skin at all. This space was granulation tissue so far as can be seen here. If the wound is now inspected, it will be found entirely dry and in excellent condition. The patient has gained materially in weight. He works in the summer time.

The second case is more important and more difficult to deal with. The young woman, when 11 years of age, had an empyema which involved the entire half of the chest. In this case, we had to perform a much more extensive operation. A roentgenogram revealed the cavities, which it required 32 ounces to fill, in order to procure an outline. Nothing remained to be done except to make a resection of the rib as high as possible and to infold the skin. Dr. Carl Beck did this first; he tried to save the breast. He amputated the breast, resecting the ribs as high as he could and implanting skin flap up into the apex. All the skin seen here is that regenerated from the edges of the flap. There was no skin grafting done, and you can judge from the roentgenograms and from the final result that skin may grow from the edges, provided adhesive plaster is used at the edges to promote regeneration.

These two cases are selected from a series of fifteen. We have had 220 of the chronic type of cases and find that 65 per cent. of them will yield to treatment without any operation whatever. We have lost practically none of these patients, and I know of but two that have had persistent discharging sinuses.

Dr. Lilienthal, in referring to a case of sarcoma, spoke about somebody having initiated this open method. I initiated it eight years ago, exposing the tumors, removing as much as possible of some to make it possible for the roentgenologist to treat these cases more efficiently. The reasons for doing this are manifold. In the first place, the roentgenologists need not apply enormous doses of roentgen and radium. He has the tumor exposed. He has practically an intrathoracic tumor converted into an extrathoracic one. He need not fear roentgen toxemia,

which is one of the greatest obstacles to this work. The tumor, before it can be eliminated by roentgen ray, has to be liquefied. When no exposure of tumor is made and it is intrathoracic, you will appreciate that every particle of the tumor substance must be first converted into liquid, and the toxic substance eliminated by way of the circulation, and in that way toxemia is produced. That is the latest opinion on the toxemia problem. When we, however, expose the tumor, not only do we remove the largest part of the tumor susbtance and thus reduce the toxic products, but we also open the way for the elimination of the débris by way of the open wound and not through the circulation.

As to the results of these cancer cases of the lung, I must say I cannot show you a case resulting in cure except it be this one. I have shown a case of a nurse from whom I removed a larger sarcoma than this from within the lung. She lived two years in good health after that, but later she had a recurrence in the abdomen, and she died a month or two ago.

Dr. Howard Lilienthal, New York: I know of Dr. Beck's work and have practiced according to his principles for many years. I was speaking, however, about the actual extirpation of cancer of the lung—not of palliative procedures.

Dr. Evarts A. Graham, St. Louis: I have had occasion repeatedly in some of these bad chronic empyemas to resort to a plastic procedure such as Dr. Beck has shown here, with good results. It seems to me that the growth and the epithelization of the wound is hastened to a marked degree by heliotherapy. We now practice that as a routine in our clinic on all such cases. After gradually working up to a good tolerance, we keep our chest patients out in the sun practically all the time. This procedure certainly diminishes the amount of secretion. As Rollier has pointed out, there is a change in the vascularity not only of the immediately surrounding area but also of the whole surface of the body to a remarkable degree. One difficulty I have had with these cases has been to speed up the epithelization in the recesses which get covered by a flap of skin. By exposing such wounds to the sun or artificial sunlight, such as a quartz light, we hasten epithelization in the darker recesses.

Dr. J. J. Singer, St. Louis: I should like to ask Dr. Beck a question: Was there an abscess in the lung, or was there the remains of an empyema? I have reference to the boy.

Dr. Beck: We could not say before that stage of the operation was performed. The parents were loath to have the boy submitted to operation, and we could not determine the condition until the roentgenogram revealed a lung abscess. There was no communication with the bronchus.

Dr. Meyer: In regard to the treatment of chronic empyema by means of bismuth paste, Dr. Emil Beck certainly has done much for his surgical confrères and for suffering humanity. He owes it to both to publish his results in full. Among the cases I have seen in which bismuth paste had been used by others for some length of time, I recall three cases of severe bismuth poisoning. All three occurred in men.

We all know from Dr. Beck's work in this line that bismuth paste is injected with great success for diagnostic purposes. In large irregular cavities, the injection of bismuth oil seems advisable for diagnostic purposes, because it is rapidly carried into all the corners and recesses of an irregular cavity and shows nicely the extent of it in the roentgenogram. Even here I have seen a severe case of poisoning at the hands of another colleague.

I am inclined to believe that severe cases of chronic empyema can be cured best by operation.

Dr. Beck has known me long enough to feel that the few words I wish to say are not to be regarded in the light of adverse criticism of his always excellent work. Attempts at epithelization of irregular deep-seated empyema cavities are certainly laudable. We all have worked with methods similar to that described by Dr. Beck. I recall in particular one case in a girl who had been operated on several times, in whom a complete cure was effected, though the case had been definitely considered incurable by others. It was necessary for me to treat the case four years, with careful stage-operating, before the task was accomplished and epithelization complete. But we must not forget that there are two ways to cure a chronic empyema. The method of decortication of the lung makes unnecessary in many instances these continued and trying attempts to accomplish epithelization of cavities that are situated deep within the chest.

Dr. James Alexander Miller, New York: It is often necessary to apply heliotherapy to the whole body in addition to the employment of local heliotherapy. There is no question about the effects of heliotherapy on tuberculosis, particularly in the surgical forms of the disease.

I have experimented with heliotherapy in chronic cases of empyema such as Dr. Beck has brought to our attention, and I am greatly interested in the results we are getting. In the last few months, we have materially improved our technic by adding heliotherapy with the high voltage roentgen ray. There is soon a closing up of chronic discharging sinuses. Heliotherapy not only aids in the healing of these chronic sinuses and hastens epithelization, but, as Dr. Graham has said, it materially aids in the clearing up of the infection.

Dr. Conrad Georg, Jr., Ann Arbor: I should like to ask whether a diagnosis of lung abscess can be made from the roentgen-ray findings. I had a case of pure empyema following influenza; the patient had none of the symptoms of lung abscess. He did not have cough or sputum, but he had an empyema, for which I operated. Healing followed, yet the roentgenogram revealed a defect in the lung. The roentgenologist said it was a lung abscess, but as the patient had none of the symptoms of a lung abscess, I have wondered whether the condition was a lung abscess or not.

Dr. Howard Lilienthal, New York: It is well to avoid the deformity of major thoracoplasty of any kind by sterilizing the cavity and permitting the wound to close. In most cases, after a time, the lung will reexpand and again occupy its normal space. The large operations of a collapsing nature such as Colonel Keller showed us at Washington last year are necessary when the lung has become atelectatic and fibrotic. He demonstrated to us many cases with great deformity which was unavoidable because, after the lung had been freed completely, it could not be made to expand. The successful termination of so many of these almost hopeless cases was certainly a great piece of work, in which Dr. Beck has been a pioneer.

Dr. Emil G. Beck, Chicago: In answer to the question regarding the reexpansion of the lung: I have tried it in a number of cases, and I am convinced that, after a lung has been out of commission for two or three years and we try to get it to function by removing the scar tissue we can only shift the lung to the other side but the air vesicles do not reopen. The main point is that, when the pleural membrane is infected, no matter what you do, the two surfaces, the visceral and the parietal, will not adhere. This operation is reserved for the septic cases in which quantities of pus continue to be discharged. The one objection is that it takes a long time for the skin to regenerate. I have come to the conclusion that, when the cavity is very large, it

would be feasible to put a few grafts not larger than a dime into the granulating surface like islands. There will be skin growing from these as from the skin edges, and the time of healing will be shortened. I do this occasionally.

Concerning what Dr. Graham said about the recesses, I have found the same trouble, and I have been able to obviate it by making these recesses shallow. The resection should be so complete that you can see every part of the cavity. We use a skin flap in order to allow the skin to regenerate.

As regards the bismuth method of treatment, I have better results today than I have ever had with this method, and up to the present time I have used it in several thousands of cases; and of this large number I have not had a single fatal case of bismuth poisoning. There is no reason why other surgeons cannot use the bismuth method without getting bismuth poisoning. If practitioners would take the time to read the literature they would see and learn how to prevent bismuth poisoning. I venture to say that 65 per cent. of all empyemas, and 85 per cent. of all other sinuses can be cured by this method.

In regard to the question of Dr. Georg concerning the diagnosis of lung abscess by the roentgen ray, I would place on it a value of about 65 per cent. as a diagnostic method. I would rather rely on a good roentgenogram, which will give more information than all the other things combined; but I would not rely on it entirely. We must make careful observations of our cases from the beginning before we operate.

When you get these cases after the patients have been operated on two or three times, so much change from the normal has taken place that it is difficult to differentiate an abscess from empyema. If a bronchus can be seen, it usually indicates the presence of an abscess. An abscess will very often perforate into the pleura. I have seen many cases in which there was a combination of abscess and empyema, so that the question as to diagnosis is really immaterial afterward. The thing to do is to obliterate the space, and that can be done in one of two ways. When the abscess cavity is small, bismuth will cure it. If it is very large, you have to resort to a radical operation.

I have given up decortication. A large surface is involved in these cases, and one cannot go through a small opening and decorticate the entire lung.

STUDIES IN INTRAPLEURAL TENSION *

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Intrapleural tension may be defined as the force which maintains expansion of the lungs under normal conditions. From another point of view it may be considered as a potential negative pressure within the pleural cavities dependent on, and caused by, the normal elasticity and contractability of the lungs.

I have studied the changes in normal intrapleural tension produced by various pathologic conditions, as well as the mediastinum of man and dog in order to determine: (1) whether there is any essential difference in the mobility of the mediastinum of man and dog, (2) whether the stability and relative strength of the structure in the two instances are comparable, (3) whether a change in the intrapleural tension of one side produces an equal change on the opposite side and, if so, by what type of mechanism, (4) whether it is possible to produce a unilateral pneumothorax in a dog, and (5) whether experimental results obtained in the dog, especially in relation to surgical pneumothorax, could be applied to man.

I have selected for publication the portion of my thesis dealing with pneumothorax. A comparison was made of pneumothorax in man and dog and certain fundamental physiologic differences emphasized which have a bearing on surgical pneumothorax.

Although pneumothorax was first recognized as a clinical entity about the middle of the eighteenth century, very few investigations of pressure relations in this condition were to be found until one hundred years later.[1] Hewson,[2] in 1767, attempted, unsuccessfully, to produce the symptoms of emphysema and pneumothorax in animals by direct injury of the lung through the chest wall. He found that animals, if left to themselves, had no marked respiratory difficulties, and recovered.

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1. Emerson, C. P.: Pneumothorax: An Historical, Clinical, and Experimental Study, Johns Hopkins Hosp. Rep. **11**:1-450, 1903.

2. Hewson, quoted by Emerson, Footnote 1, pp. 11-13.

Cruveilhier,[3] in 1836, opened both pleural cavities in a dog, and, after a temporary cessation of respiration, the animal if left to itself recovered completely. Cruveilhier believed this to be contrary to the earlier teachings of Van Swieton [4] that opening both sides of the pleura was fatal when the combined openings were larger than the glottis. Powell,[5] in 1868, demonstrated at necropsy a positive pressure of 10 cm. of water in a case of spontaneous tuberculous pneumothorax. He found an opening in the lung with a valve arrangement of the pleura.

Weil [6] divided spontaneous pneumothorax into three types: (1) closed pneumothorax, in which the pulmonary fistula has become closed, preventing the entrance of air in either inspiration or expiration; (2) open pneumothorax, in which air has free entrance to, and exit from, the pleural cavity, and (3) valvular pneumothorax, in which the fistula is open on inspiration and closed on expiration.

Sehrwald,[7] as the result of experimental investigation on animals, drew the following very accurate conclusions as to the mechanics of open pneumothorax: (1) The effect on respiration of a unilateral pneumothorax opening externally depends not on the absolute size of the opening, but on the relation of its size to that of the bronchus of that lung. (2) The second determining factor for the ventilation of the sound lung is the nature of the mediastinum; if it is thin and distensible each inspiration will aspirate it so much to the good side that it hinders the dilatation of that lung. (3) For this reason young persons and those with a normal mediastinum do not endure pneumothorax so well as those in whom the mediastinum has become a thick, stiff membrane. (4) In inspiration the descent of the diaphragm stretches the mediastinum and thus aids the sound side. (5) In order to force the collapsed lung to take some part in respiration again it is well to close the thoracic opening at the end of forced expiration.

Dwyer,[8] by a few well selected experiments, demonstrated that in pneumothorax the collapsed lung is expanded by the air forced into it from the sound lung. This cannot occur if by free incision into the trachea constriction of the glottis is prevented.

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3. Cruveilhier, M.: De l'empyème et de quelques expériences sur les animaux, Bull. de l'Acad. de méd. **1**:280, 1836.

4. Van Swieton, quoted by Cruveilhier, Footnote 3.

5. Powell, R. D.: Lung Showing Perforation, from a Case of Pneumothorax, Tr. Path. Soc. London **19**:77-79, 1868.

6. Weil, A.: Zur Lehre vom Pneumothorax, experimentelle und klinische Untersuchungen, Deutsch. Arch. f. klin. Med. **25**:1, 1879-1880; Weitere Mittheilungen über Pneumothorax, ibid. **40**:1-30, 1886-1887.

7. Sehrwald, quoted by Emerson, Footnote 1, p. 131.

8. Dwyer, quoted by Emerson, Footnote 1, pp. 132-133.

Auquier,[9] in 1882, emphasized the importance of another factor besides negative intrapleural tension in maintaining the expansion of the lungs in the thoracic cavity. He says that Dolbeau and Smith,[10] in 1862, maintained that a molecular force greater than the elasticity of the lungs existed between visceral and parietal pleuras and kept them in contact. This force they likened to the cohesion between two plates of wet glass. Auquier corroborates this view and asserts that an intrapleural vacuum does not exist, but that when a trocar is introduced between the pleural layers normal conditions are altered and a pneumothorax is produced. All measurements so obtained, he believes are false and do not show the true state of affairs.

Barr,[11] West,[12] Tendeloo,[13] Brauer,[14] Macewen,[15] Roth[16] and others sustained the cohesion theory in numerous articles. They insisted that the parietal pleura could not be opened without mechanically causing a slight local separation of the two pleural surfaces, with a resultant small pneumothorax, after which further separation might occur as a result of the pleural surfaces rolling back from each other. The pulmonary elasticity might then become effective.

Murphy[17] could find no evidence of such cohesive force. He also discussed varous factors concerned in surgical pneumothorax. He found that in dogs the anterior mediastinum was thin, that sometimes there was an opening between the two pleural cavities and that in certain types of animals such an opening was normally present. When it was not present in the dog the mediastinum was easily ruptured. In expiration with an open pneumothorax, the lung appeared to come

9. Auquier, E.: Du rôle des tensions et des pressions intra-thoraciques dans le pneumothorax traumatique, Gaz. hebd. d. sc. méd. de Montpelier **4**: 557, 598, 609, 617, 1882.

10. Dolbeau and Smith, quoted by Auquier, Footnote 9.

11. Barr, J.: The Pleurae: Pleural Effusion and Its Treatment, Brit. M. J. **2**:1289-1295, 1907.

12. West, S.: Cases of Pneumothorax, Tr. Clin. Soc. London **19**:227-239, 1886; Pneumothorax, Brit. M. J. **2**:393-400, 1887; Intrapleural Tension, Med. Chir. Tr. **81**:273-299, 1898.

13. Tendeloo, quoted by Brauer, Footnote 14.

14. Brauer, L.: Die Ausschaltung der Pneumothoraxfolgen mit Hilfe des Ueberdruckverfahrens, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **13**:483-500, 1904; Der Druck zwischen den beiden Pleurablättern, Beitr. z. path. Anat. u. z. allg. Path. **7**:762-776, 1905.

15. Macewen, W.: Some Points in the Surgery of the Lung, Brit. M. J. **2**:1-7, 1906.

16. Roth, J.: Ueber den interpleuralen Druck, Beitr. z. Klin. d. Tuberk. **4**: 437-446, 1905-1906.

17. Murphy, J. B.: Surgery of the Lung, J. A. M. A. **31**:151-165 (July 23) 1898.

closer to the chest wall while in reality it contracted the hilums. If there was resistance to the exit of air from the trachea in expiration, as by narrowing of the glottis, air from the uninjured lung was forced across and distended the collapsed lung. This was noted in three cases in human beings. Murphy concludes, "I am convinced that the dyspnea following opening of the pleural cavity is due to the vibration of the mediastinal septum and its contents, destroying the piston action of the diaphragm." Under such conditions a "pendulum movement" of air ensues from one lung to the other, and no effective exchange of air occurs with the outside. This condition can be relieved by covering the pneumothorax opening or by traction on the collapsed lung to steady the mediastinum.

The work of Garrè and Quincke,[18] in 1912, may be taken as typical of the general opinions held with regard to pneumothorax to this date. The size of the opening in the pleura is said to be of decisive importance. With an opening smaller than the trachea a slight negative pressure is produced in the affected side with each inspiration, and some air enters the collapsed lung. The function of the other lung depends on the position of the mediastinum, and this depends on the pressure exerted on it. With equal pressure on the two sides, it will not change. However, in pneumothorax with a small opening, there is marked difference in the pressures of the two sides; the mediastinum is displaced toward the sound side, and a complete expansion of the sound lung cannot occur. In expiration, especially if forced, the pressures become positive, and the mediastinum is forced away from the sound lung and bulges toward the pneumothorax. Some air from the sound lung will also enter the collapsed lung. In spite of the difficulties, an opening smaller than the glottis can be compensated for, and dangerous symptoms do not appear. However, with a wide open pleura the air enters and leaves so easily that the lung is functionless. Mediastinal flutter is more marked, and inspiration and expiration become insufficient. There occurs a pendulum movement of air from one lung to the other with respiratory efforts, and adequate gas exchange with the exterior does not occur.

Graham and Bell,[19] in 1918, deduced radically different conclusions as the result of their experimental investigations. They said, "For all practical purposes . . . the thorax may be considered as one cavity instead of two. Any change of pressure in one pleural cavity will affect also the other one almost equally. The common conception of collapsed lung on one side and healthy or normal lung on the other,

18. Garrè, C., and Quincke, H.: Lungenschirurgie, Jena, Fischer, 1912, p. 21.

19. Graham, E. A., and Bell, R. D.: Open Pneumothorax; Its Relation to the Treatment of Empyema, Am. J. M. Sc. **156**:839-872 (Dec.) 1918.

in the condition of open pneumothorax in the otherwise normal chest, must be erroneous. The dog's mediastinal structures have the same mobility as those of the human being; therefore, experimental results obtained on the living dog are applicable to man." Parallelism of thoracic pressure relation in dogs and in human beings was demonstrated by injecting air into one pleural cavity until a pressure of 10 cm. of water was reached and by observing the pressure recorded by the opposite pleura. Observation on human cadavers and dead dogs revealed pressures of from 9 to 9.5 cm. of water in the opposite pleural cavity in each case. Five human cadavers were employed; two were of infants of 4 months and 14 months, respectively, one of a child, aged 14 years, and two of adults. The authors conclude, "It is clear, therefore, that the distribution of the pressure from one pleural cavity to the other under the conditions of the experiment was due to the fact that the mediastinal structures were pushed over against the opposite lung. Furthermore, under a pressure equivalent to 10 cm. of water, the rigidity of the mediastinal partition between the pleural cavities in both dogs and the humans . . . is practically negligible." The relative density of the lungs of dogs and man, under the same degree of collapse, was compared and found to be similar. As similar results were obtained in living and dead dogs, it was thought that experimental results obtained in living dogs could be directly applied to the living human being. A marked difference in the behavior of the animal was noted, depending on the size of the pleural opening in relation to the glottis. With a large opening, despite maximal respiratory efforts, the animal was unable to establish a negative pressure in the pleural cavity, and, therefore, was unable to draw air into the lungs, or if able to establish a slight negative pressure it might still be unable to obtain sufficient air to maintain life. No such thing as a unilateral collapse was possible for both lungs must function equally since practically equal pressures are present in both pleural cavities. "In the normal chest the action of the lungs, as a whole proceeds practically as if no mediastinum were present, since the pressures in the two pleural cavities are always the same." Again, "A double open pneumothorax in a normal chest is more dangerous to life than a unilateral open pneumothorax merely because usually the combined areas of the two openings . . . is greater than a single opening on one side is likely to be." The size of a pleural opening compatible with life, it was found, bore a definite relation to the area of the glottis, expressible by a mathematical formula. For man the maximal opening compatible with life for short periods was calculated to be 5 by 10 cm. In a later

article Graham [20] corrects their data, giving an area of 101.3 sq. cm. as the maximal nonfatal opening.

Graham's conclusions, from a clinical standpoint, appear open to question. The experience of military surgeons during the late war seems to emphasize the relative safety of unilateral surgical pneumothorax. Matas,[21] in a recent article, discusses the general apparent indifference of the French surgeons to the dangers of pneumothorax.

Hedblom,[22] in speaking of open pneumothorax, says, "It is obviously not only possible but reasonably safe, so far as the immediate risk to the life of the patient is concerned, to open wide the pleural cavity without differential pressure anesthesia."

PNEUMOTHORAX

These studies in pneumothorax were undertaken with the object of comparing the pressure relations in dog and in man, the behavior of the mediastinum being particularly noted in each case. The opportune work of Graham and Bell was undoubtedly responsible for the saving of many lives during the recent epidemics of influenza. I have endeavored to reexamine the mechanics involved in pneumothorax and to see whether any new factors could be elicited. If Graham and Bell's conclusions are correct, the mediastinum must behave similarly in dog and in man under equal unilateral changes of pressure. The evidence seemed to prove that such similarity existed not only between the dead dog and the dead human being, but between the dead and the living dog. Results obtained on the living dog could, therefore, very justly be applied to the living human being.

The first experiments were carried out on dead dogs, usually from one hour to six hours after death. The dogs were placed directly on their backs on the table of a roentgen-ray machine and held in this position by supports and straps. A plate-changing tunnel was placed beneath the thorax and a Coolidge tube centered over the sternum. In this manner, without disturbing either animal or tube, multiple roentgenograms could be taken with the animal in the same position. It was hoped by this means to show the deviation of the mediastinal structures on the production of a unilateral pneumothorax. Two water manometers were connected by thick-walled tubing to two

20. Graham, E. A.: The Maximum Nonfatal Opening of the Chest Wall, J. A. M. A. **73**:1934-1935 (Dec. 27) 1919.

21. Matas, Rudolph: The Value of Artificial Aids to Respiration in "Acute Operative Collapse of the Lungs" (Surgical Pneumothorax) Occurring in the Course of Intrathoracic Operations, Arch. Surg. **5**:110-133 (July) 1922.

22. Hedblom, C. A.: Open Pneumothorax in Its Relation to the Extirpation of Tumors of the Bony Chest Wall, Arch. Surg. **4**:588-597 (May) 1922.

15 gage needles (Fig. 1). A Y was interposed in the center of the tubing, and to one branch of the Y a hand pressure bulb was attached. After clamping off each pressure bulb to prevent leakage, the needles were inserted into each pleural cavity. When the pleural cavity was reached negative pressure was registered by the manometer, and intermittent pressure on the thorax caused fluctuations of the manometer.

The pressures obtained from each pleural cavity were first noted and a roentgenogram taken of the thorax, then the clamp was removed

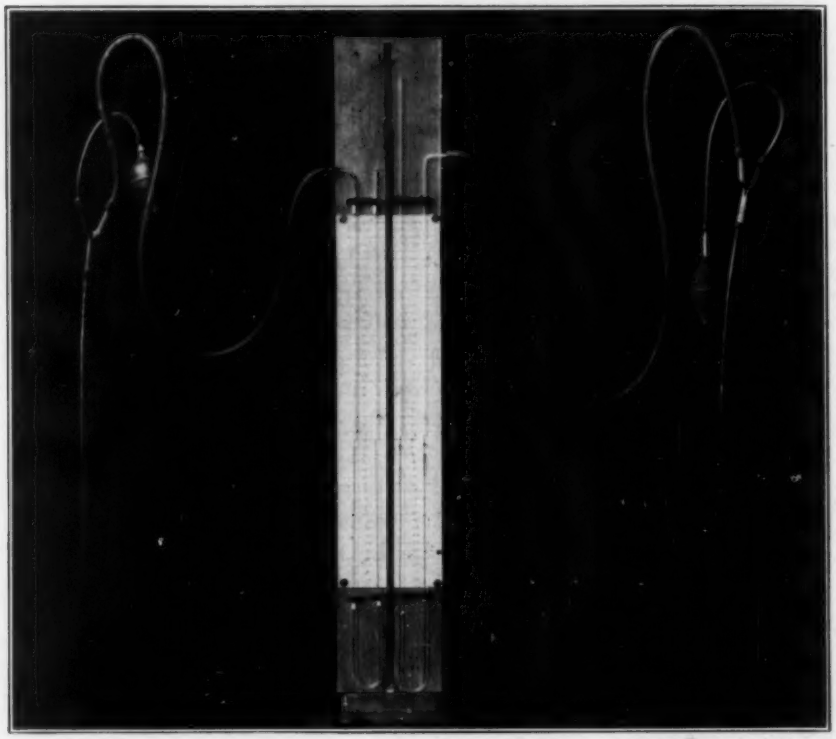

Fig. 1.—Water manometers assembled with Y tubes and pressure bulbs for bilateral pressure determinations in artificial pneumothorax.

from one hand bulb, and air was pumped into the pleural cavity until a positive pressure was reached. The readings on each side were then noted and a second roentgenogram of the thorax was taken. Following this, one side of the thorax was opened and the mediastinum brought under direct observation. Air was then pumped into the opposite pleura with the idea of producing displacement of the mediastinum and finally rupture.

The first four experiments, on dead animals, were not entirely satisfactory because of technical faults, and are not described here.

The abdomen was opened in each case to obviate abdominal transmission of pressure.

REPORT OF EXPERIMENTS

EXPERIMENT 6.—A dog not previously operated on had been dead for six hours. The abdomen was opened. The pressure of the right pleura was negative, measuring —4 cm. of water, of the left, —4 cm. A roentgenogram was taken (Fig. 2). Air was forced into the left pleura. The pressure of the right pleura was + 10 cm. of water, of the left, + 10 cm. A second roentgenogram was taken (Fig. 3).

Fig. 2.—Appearance of the chest before the inducement of pneumothorax.

The right pleura was opened very carefully on the side of the thorax, the mediastinum being carefully preserved, as described. In the hope that a natural opening said to exist sometimes between the two pleural cavities might be found, the left side of the thorax was opened, thus preserving the mediastinum as an intact septum between the two sides. The dog was turned slightly on one side, and one pleural cavity was filled with water. This passed freely through the anterior mediastinum into the opposite pleura. No natural opening could be found, but the anterior mediastinum seemed to be freely permeable to water. Pathologically, the lungs revealed moderate bronchopneumonia. The second roentgenogram did not show deviation of the mediastinum, and a bilateral pneumothorax was present.

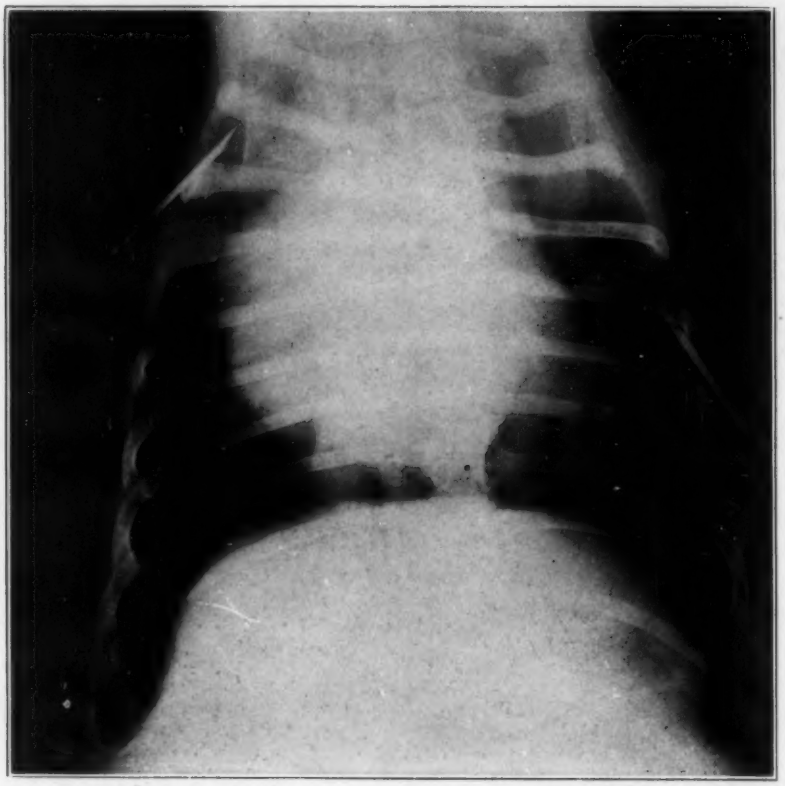

Fig. 3.—Appearance of the chest after air was injected into the left pleural cavity with the production of a bilateral pneumothorax.

Fig. 4.—Appearance of the chest before the introduction of potassium bromid solution.

Experiments, 5, 7, 8, 9, 11, 15 and 16 were repetitions of Experiment 1. After opening one pleural cavity it was found impossible, by the most vigorous pumping, to raise the pressure in the unopened pleura 0.5 cm. of water. Fluids passed readily from one pleural cavity to the other.

EXPERIMENT 10.—The dog had been dead eight hours. The abdomen had been opened for a previous operation. The pressure of the right pleura was —4 cm. of water, of the left, —4 cm. A roentgenogram was taken (Fig. 4).

Fig. 5.—Appearance of the chest after the introduction of potassium bromid solution into the left pleural cavity, showing bilateral distribution.

Three hundred and fifty cubic centimeters of 10 per cent. potassium bromid solution was run into the left pleural cavity from an elevation of 25 cm. in ten minutes. The pressure of the right pleura was + 16 cm. of water, of the left pleura, + 20 cm. A second roentgenogram was taken (Fig. 5). The right pleura was opened and found partly full of fluid, with about an equal amount on the left. Pathologically, the lungs and pleura were negative except for a small adhesion at the left base. The second roentgenogram showed about an equal amount of the opaque solution in each pleural cavity.

Experiments 12 and 13 were repetitions of Experiment 10. In each instance the roentgenogram of the chest showed a bilateral distribution of the fluid which evidently had penetrated the intact mediastinum.

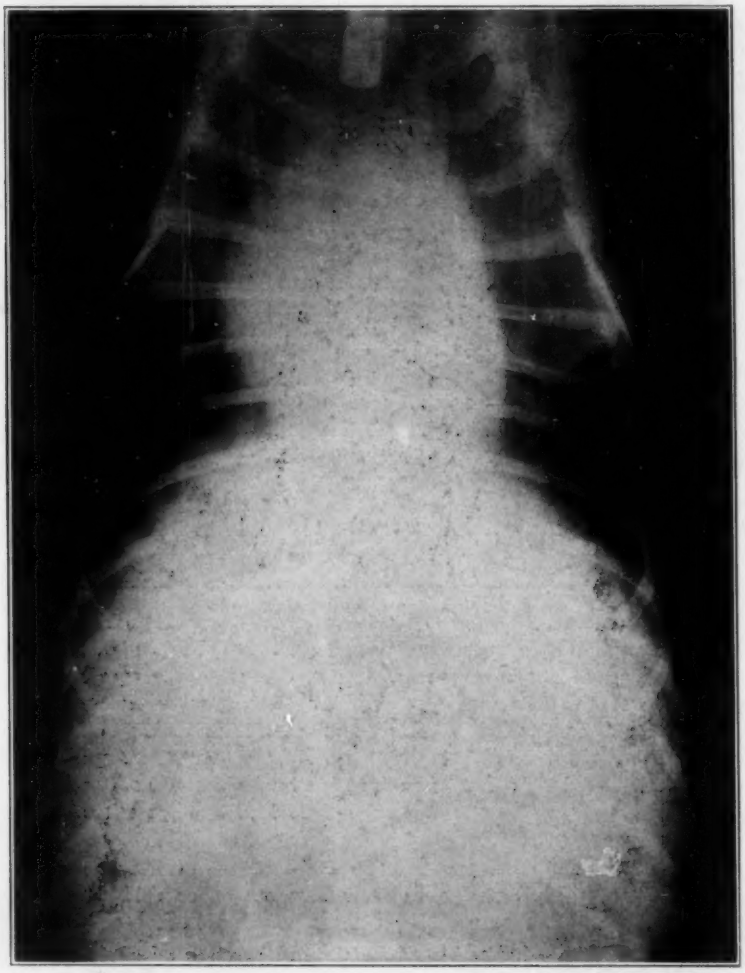

Fig. 6.—Appearance of the chest of living animal before the introduction of potassium bromid solution.

Presuming from these experiments that a unilateral pneumothorax could not be produced in the dead dog but that it was always bilateral, I proceeded to test this in a different manner. By freeing the trachea of a dog and tying it tightly about a large glass tube, it could be connected to our water manometer. Opening one pleura

we could then produce collapse of the lung and a positive pressure in the trachea, as shown by the manometer. If by opening one pleural cavity in the dog a bilateral pneumothorax is produced, the opening of the second pleural cavity should cause no change in the pressure

Fig. 7.—Appearance after the introduction of potassium bromid solution into the right pleural cavity, showing bilateral distribution.

level already obtained. In three animals the procedure showed that the opening of one pleural cavity secured the maximal elastic recoil of the lungs, and subsequent opening of the opposite pleural cavity caused no change in the level of the manometer. The experiments previously made on dead animals were now repeated on living animals.

EXPERIMENT 18.—The abdomen of a dog, weighing 13 kg., was opened for operation using full ether anesthesia. At 3:00 p. m. the pressure of the right pleura was from —4 to —11 cm. of water, of the left pleura from —1 to —10 cm. A roentgenogram was taken. One hundred cubic centimeters of air was injected into the right pleural cavity. At 3:05 p. m. the pressure of the right pleura was from 0 to —10 cm. of water, of the left from 0 to —9 cm. A second roentgenogram was taken. Again 100 c.c. of air was injected into the right pleura. At 3:09 p. m. the pressure of the right pleura was from + 1 to —9 cm. of water; of the left pleura from 0 to —8 cm. A third roentgenogram was taken. One hundred cubic centimeters of air was injected into the right pleura. At 3:11 p. m. the pressure of the right pleura was from + 2 to —8 cm. of water; of the left pleura from + 1 to —7 cm. A fourth roentgenogram was taken. At 3:14 p. m. 100 c.c. of air was injected into the right pleura. The pressure of the

Fig. 8.—Simultaneous tracings (under ether anesthesia) of the pleural pressures of each side during the injection of air into the right pleural cavity. The upper curve represents the left pleural pressure and the lower curve the right pleural pressure. The corresponding base lines were drawn at atmospheric pressure. The points *a*1, *a*2, *a*3, and so forth, indicate the time at which the corresponding roentgenograms (Figs. 9, 10, 11, 12 and 13) were made. The arrows below the curves designate the points at which air in 200 c.c. amounts was injected into the right pleural cavity.

right pleura was from + 3 to —8 cm. of water; of the left from + 2 to —7 cm. of water. A fifth roentgenogram was taken. At 3:17 p. m. 100 c.c. of air was injected into the right pleura. The pressure of the right pleura was from + 2 to —8 cm. of water; of the left from + 1 to —6 cm. A sixth roentgenogram was taken. At 3:20 p. m. 100 c.c. of air was injected into the right pleura. The pressure of the right pleura was from + 5 to —8 cm. of water; of the left from + 5 to —8 cm. A seventh roentgenogram was taken.

The animal died at this time, and after death the pressure was + 2 on each side. An eighth roentgenogram was taken after death. Immediately 200 c.c. of a 10 per cent. solution of potassium bromid was run into the left pleural cavity from an elevation of 15 cm., requiring three minutes. The pressure of the right pleura was + 4 cm. A ninth roentgenogram was taken. An additional 200 c.c. of potassium bromid solution was run into the pleural cavity in three minutes' time. The pressure of the right pleura was + 6 cm. A tenth roentgenogram was taken. Pathologically, the lungs and pleura were negative. The roentgenograms again

demonstrate a bilateral pneumothorax without deviation of the mediastinal structures. The chest also showed increasing distention, evidently the animal's attempt to compensate for the pneumothorax and maintain a negative pressure within the pleural cavity. It will be noted that a negative inspiratory pressure was maintained as long as the animal lived. After death the pressure became positive.

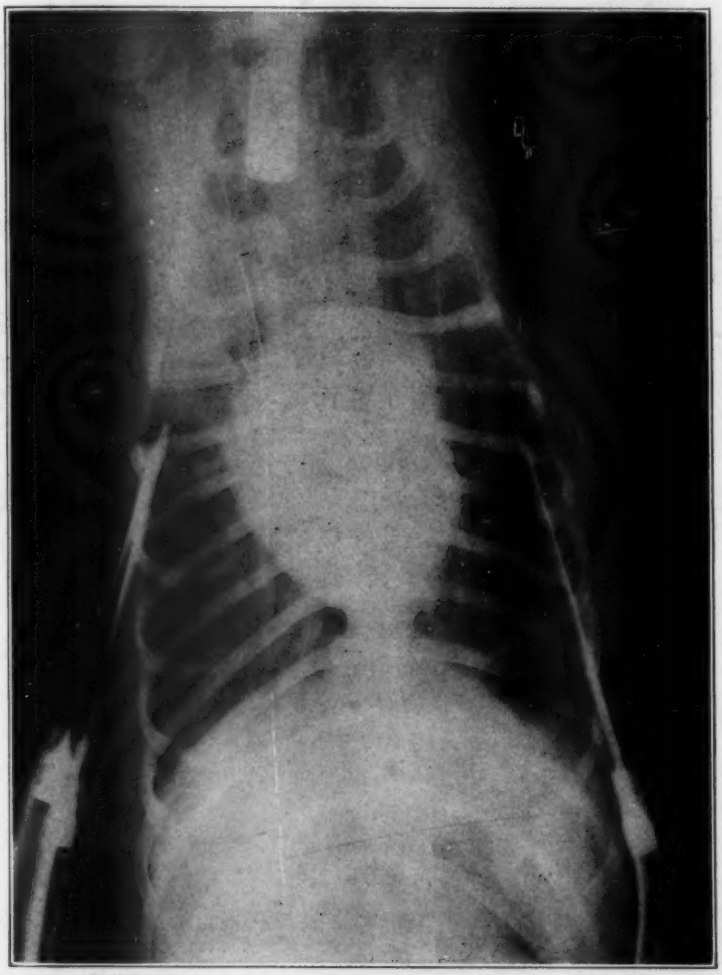

Fig. 9.—Appearance of the chest at the time indicated by the point marked *a*1 in Figure 8. In this illustration and in Figures 10, 11, 12 and 13, the close similarity of the curves of the two pleural pressures is evident, as well as the development of a bilateral pneumothorax without displacement of the mediastinum.

On opening the right pleural cavity bromid solution was present; but this failed to show in the ninth and tenth roentgenograms, probably because the animal in its agonal struggle turned to the left side and so pocketed the solution in the left pleura.

Experiments 19, 21 and 23 were repetitions of Experiment 18, employing the living animal. In each case a bilateral pneumothorax was present with no deviation of the mediastinal structures.

In Experiments 20 and 22 potassium bromid solution was intro-

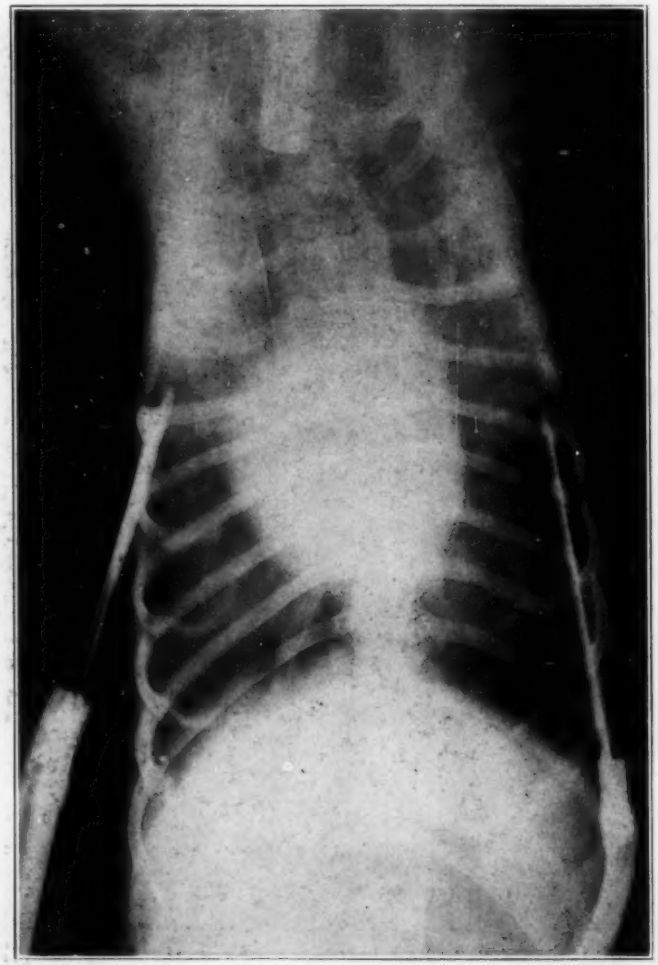

Fig. 10.—Appearance of the chest at the time indicated by the point marked *a* 2 in Figure 8.

duced into one pleural cavity. Both animals showed a similar bilateral distribution of the solution (Figs. 6 and 7).

In three dogs (Dogs 25, 28 and 29) graphic tracings of the pleural pressures were made by arranging two water manometers having floats attached to writing arms, the points of which were placed in contact

with the smoked drum of a kymograph. By this arrangement all oscillations of the manometer could be directly recorded on the drum of the kymograph (Figs. 8, 9, 10, 11, 12 and 13).

Two dogs were used to investigate the existence of cohesive force between visceral and parietal pleura, as described by Auquier.

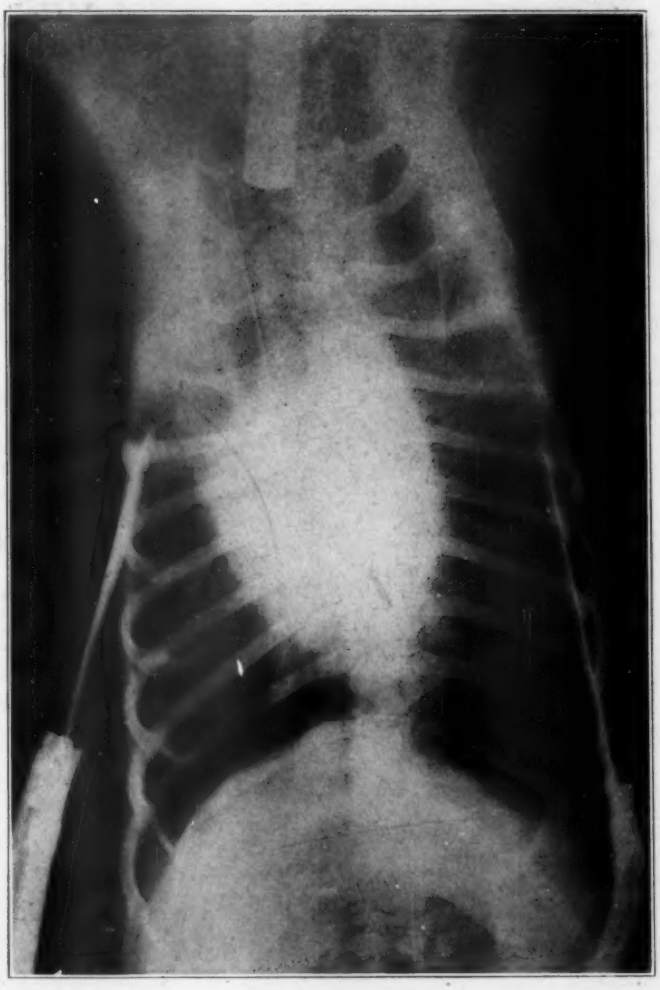

Fig. 11.—Appearance of the chest at the time indicated by the point marked *a* 3 in Figure 8.

EXPERIMENT 30.—The dog had been dead twelve hours. A roentgenogram was taken. The right pleural cavity was opened. A second roentgenogram was taken which revealed the presence of a bilateral pneumothorax.

EXPERIMENT 31.—A roentgenogram was taken three hours after the death of a dog weighing 6.7 kg. The right pleura was opened. A second roentgenogram

was taken which also revealed the existence of bilateral pneumothorax. The fact that both dogs showed a bilateral pneumothorax which occurred as readily on the side opposite the injury as on the side of the injury itself would seem to disprove the existence of a cohesive force between the two pleural surfaces.

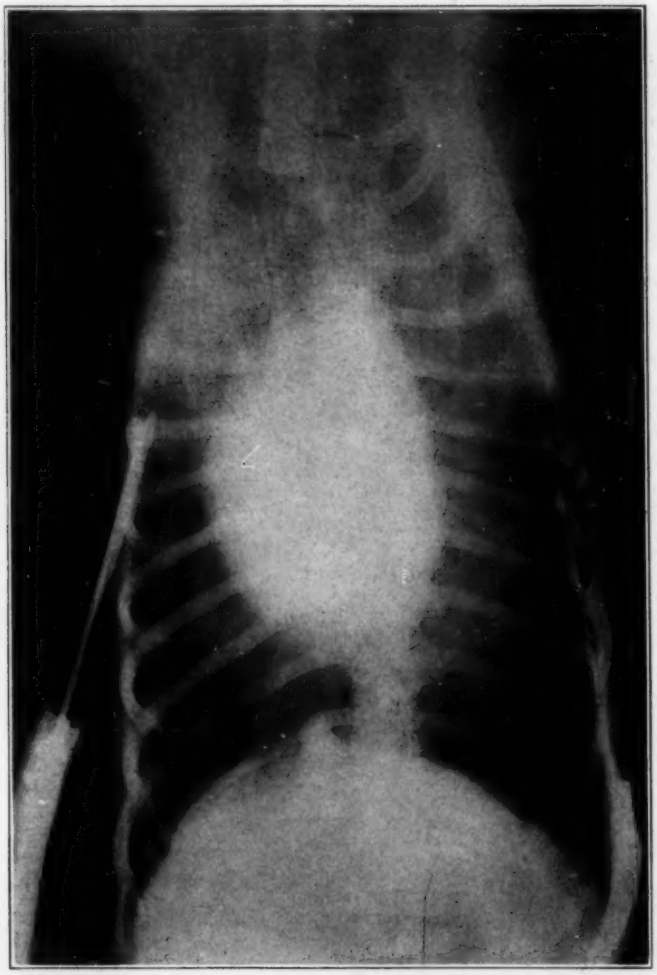

Fig. 12.—Appearance of the chest at the time indicated by the point marked *a* 4 in Figure 8.

The following series of experiments was carried out on human cadavers to ascertain as closely as possible the parallelism between pressure relations in dog and man.

Case 1.—H. W. R., aged 6 years, died June 30, 1922, of septic cerebrospinal meningitis following operative repair of spina bifida. At necropsy two hours after death the pressure of the right pleura was —3 cm. of water, and of the

left pleura, —3 cm. Air was forced into the right pleura. The pressure of the right pleura was + 10 cm. of water, and of the left pleura, —0.5 cm. More air was forced into the right pleura. The pressure of the right pleura was + 26 cm. of water; of the left, + 1 cm. After a few seconds the pressures

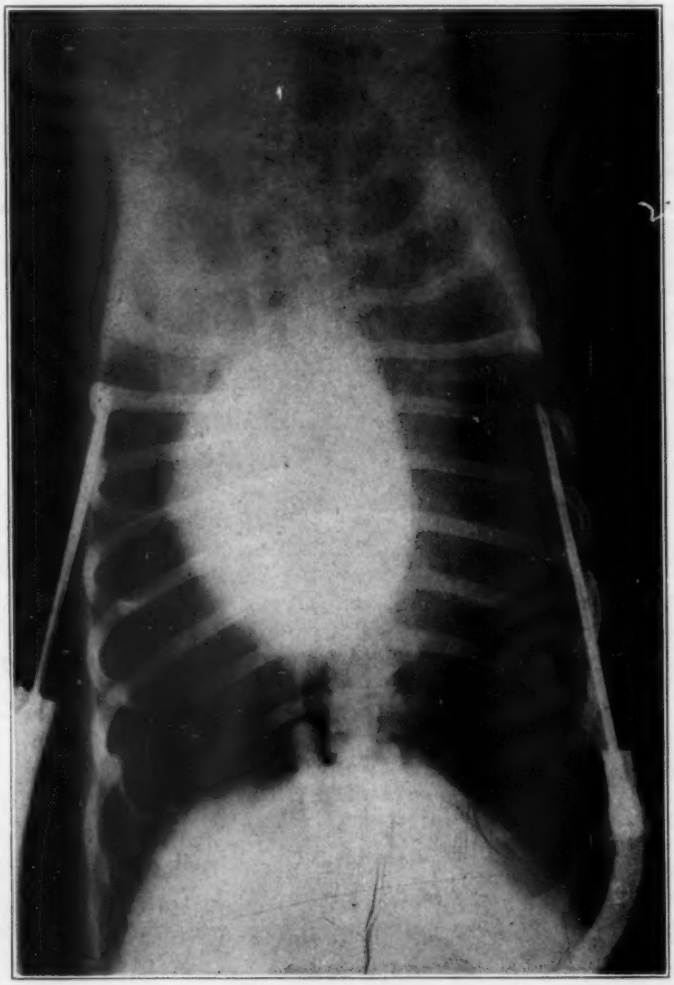

Fig. 13.—Appearance of the chest at the time indicated by the point marked *a* 5 in Figure 8.

changed to + 20 cm. of water in the right pleura, and + 2 cm. in the left. The abdomen was then opened. The pressure of the right pleura fell to 10 cm. of water, and of the left to —1 cm. Air was forced into the right pleura. The pressure of the right pleura was + 15 cm. of water; of the left, + 1 cm. The left pleura was opened. The pressure on the right fell to + 11 cm.

Air was then forced into the right pleural cavity until a pressure of + 60 cm. of water was reached. The liver was forced well down into the abdomen, and

the heart displaced beyond the left chest wall. Both lungs were free from adhesions, and the pleural cavities contained no fluid. There was no evidence of pneumonia.

Eleven other human cadavers were employed with essentially similar results. Case 4 is of some interest because it shows zero intrapleural tension.

Case 4.—Baby H., aged 3 days, died at 7 p. m., Aug. 9, 1922. Necropsy was held at 9 p. m. The cause of death was melanoneonatorum. The pressure of the right pleura was 0 cm. of water; of the left, 0 cm. Air was forced into the right pleura. The pressure of the right pleura was + 22 cm. of water; of the left + 1 cm. On opening the abdomen the pressure on the right fell to + 14 cm. The left pleura was opened, and the pressure on the right fell to + 10 cm. Then air was pumped into the right pleura until a pressure of + 50 cm. of water was reached. The liver was forced well into the abdomen, and the heart displaced outside the left chest wall. The lungs were free from adhesions, and the anterior mediastinum at the thinnest place appeared to be a relatively substantial membrane.

In Case 8 bromid solution was employed, and a unilateral distribution was evident by roentgen-ray examination.

Case 8.—J. E. G., man, aged 42, died from cerebral tumor at 9 p. m., Sept. 13, 1922. Necropsy was performed at 8:30 a. m., September 14. The pressure of the right pleura was — 3 cm. of water; of the left, — 4 cm. A roentgenogram was taken. The abdomen was opened, no change in pressure resulting. Air was forced into the left pleural cavity. The pressure of the right pleura was + 10 cm. of water; of the left, + 11 cm. A second roentgenogram was taken. More air was forced into the left pleura. The pressure of the right pleura was + 20 cm. of water; of the left, + 32 cm. of water. A third roentgenogram was taken. Two hundred cubic centimeters of 10 per cent. potassium bromid solution was run into the left pleural cavity. A fourth roentgenogram was taken.

From the roentgenograms a marked displacement of the mediastinum was evident. The bromid solution appeared to be confined to the left pleural cavity. Both pleural cavities were free from adhesions.

There were two cases of bilateral pleural effusions in which pressure determinations were made simultaneously in each pleural cavity, care being taken that the aspirating needles were inserted at the same level on the two sides.

Case 22.—J. S., man, aged 49, had malignant hypertension, cardiac hypertrophy and dilatation, and left hydrothorax. With the patient sitting erect, the initial pressures were from + 3 to + 2 cm. of water in the right pleura; in the left, from + 6 to + 8 cm. Nine hundred cubic centimeters was aspirated from the left pleura, and 200 c.c. from the right.

Case 23.—Mr. J. B., a farmer, aged 68 years, had had an attack of dyspnea, tachycardia and fever one year before, lasting for one month. He fully recovered; but six weeks before admission he developed cough, dyspnea and slight hemoptysis, and had become progressively weaker with the development of anemia and general anasarca. A diagnosis was made of chronic myocardial

degeneration, auricular fibrillation, decompensation and right pleural effusion. July 12, 1922, the initial pressures with the patient sitting erect were from +3 to +4 cm. of water in the left pleura, and from +8 to +9 cm. in the right. Ten cubic centimeters of clear yellow fluid was aspirated from the left pleura, and 850 c.c. of serosanguineous fluid from the right. July 14, the initial pressures with the patient sitting erect were from −2 to −3 cm. of water in the left pleura, and from +5 to +6 cm. in the right. Ten cubic centimeters of clear yellow fluid was aspirated from the left, and 750 c.c. of serosanguineous fluid from the right. At necropsy four days later the pressure on the right was +12 cm. of water and on the left, −3 cm. Air was then pumped into the right pleura until a pressure of +47 cm. of water was shown. At this time the pressure on the left became +7 cm. The heart showed hypertrophy and dilatation. There was hemorrhagic infarction of both lungs, and the right pleura presented a hemorrhagic putrefactive empyema with from 1,000 to 1,500 c.c. of fluid. There were a few adhesions around the hilum of the left lung. About 100 c.c. of serous fluid was found on the left side. As will be noted, the pressures on the two sides of the thorax are not identical in either of the two cases.

COMMENT

From the foregoing experiments it would seem evident that unilateral pneumothorax does not occur in the dog. Conclusions drawn from experiments on the dog, in which the parallelism of the two pleural pressures was explained by displacement of the mediastinum, are evidently erroneous. A bilateral pneumothorax must exist in each case. The anterior mediastinum in the dog is of the thinness of paper, permeable to both air and fluids, while in man it is a membrane of some thickness and considerable resistance. A "weak place" is described in the posterior mediastinum in both dog and man, posterior to the heart. In the dog this area is permeable to fluids in some cases and not in others. Permeability of the dog's mediastinum to fluids, we find, is not a new observation. Garland,[23] in 1878, after injecting malted cocoa butter into a dog's pleura noted a bilateral distribution, and Calvert[24] states, "The mediastinum of a dog readily permits fluid to flow from one pleura into the other."

In man neither the anterior nor the posterior mediastinum is permeable to air or fluids. The changes of pleural pressure in man on the side opposite a pneumothorax are caused by displacement of the mediastinum. While the pressures on the two sides are comparable, they are not identical, as in the dog. Burrell and MacNalty,[25] as the

23. Garland, G. M.: Pneumonodynamics, New York, Hurd and Houghton, 1878, p. 53.

24. Calvert, J.: On the Intrapleural Pressure and Manner of Contraction of the Lung in Pleural Effusion, St. Barthelomew's Hosp. Rep. **28**:131-135, 1892.

25. Burrell, L. S. T., and MacNalty, A. S.: Report on Artificial Pneumothorax, Medical Research Council, London, 1922.

result of taking bilateral pressures in induced pneumothorax, say, "It may be concluded, therefore, that in compressing one lung by artificial pneumothorax one does not interfere with the pressure in the opposite pleural cavity, even if the mediastinum is displaced." In contrast to this, Simon,[26] as the result of observations of bilateral pressure in three cases of artificial pneumothorax, says, "An artificial pneumothorax on one side of the chest affects the intrapleural pressure on the opposite side, and this effect is probably transmitted to the corresponding lung." He found an average difference of pressure of only 1 cm. of water between the two sides.

There was no opportunity to take bilateral pleural pressures in cases of artificial pneumothorax. However, the observations in Cases 22 and 23 of bilateral pleural effusions disclosed a notable difference of pressure on the two sides at the same level. If the mediastinum could be ignored as a factor, the pressures would be identical. Weitz,[27] in one case of bilateral effusion, found a difference of 6 cm. of water between the two sides, increasing to a difference of from 11.5 to 13.5 cm. after aspiration. A slight variation in the intrapleural tension on one side may be compensated for by a shift in the mediastinum, and equal pressures will again be established on the two sides. However, with a decided change on one side, as with open pneumothorax, the natural resistance of the human mediastinum is exerted, and equal pressures do not exist. I have never been able to rupture a human mediastinum with pressures up to 50 cm. of water. It, therefore, seems to have considerable stability. The thickness of the anterior "thin portion" of the mediastinum varied, largely depending on the amount of adipose tissue between the two pleural surfaces; but an example of fibrosis, which is mentioned so frequently, was not observed.

Perls'[28] early experiments on 100 consecutive cadavers in which both pleural cavities were opened in turn and in which each lung, unless firmly adherent, registered its own elastic tension on a manometer connected with the trachea would seem to bear out my contention. If the pressures on the two sides were identical, opening of the second pleural cavity should show no further change in the level of the manometer. The first lung often registered twice or three times as much as the second; but if the mediastinum could be ignored the second lung would not register an additional pressure. Therefore,

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26. Simon, S.: The Effect of Artificial Pneumothorax on the Collateral Lung, Am. Rev. Tuberc. **5**:620-636 (Oct.) 1921.

27. Weitz, W.: Ueber den Druck in Pleuraergüssen, Deutsch. Arch. f. klin. Med. **92**:526-550, 1908.

28. Perls, M.: Ueber die Druckverhältnisse im Thorax bei verschiedenen Krankheiten, Deutsch. Arch. f. klin. Med. **6**:1-5, 1869.

experiments conducted on dogs with relation to pneumothorax may not be applied directly to man; but due attention should be given to the differences in anatomy and physiology in the two.

Cohesion as a factor in maintaining expansion of the lung may be ignored. No evidence could be found of its existence in the dog, for collapse of the lung on the uninjured side occurred normally.

Normal negative intrapleural tension is dependent on the elastic recoil of the lungs. By expansion of the chest or descent of the diaphragm the lungs are stretched and their power of elastic recoil increased, and with it the negative intrapleural tension. Coughing, or other forced expiratory acts, by decreasing the capacity of the thorax, produces a positive intrapleural pressure associated with a compression of the lungs unless prevented by closure of the glottis. The normal range of intrapleural tension in the adult during quiet respiration varies from —7 to —9 mm. of mercury with inspiration and from —3 to —5 mm. of mercury with expiration. In the infant the intrapleural tension is zero, as the lungs completely fill the thorax. With increasing age the thorax seems to grow away from the lungs and a negative intrapleural tension is established. Normally, there is a perfect balance in the tension of the two sides of the thorax. Unequal expansion of the two sides of the thorax may, however, cause a slight difference. Changes of moderate degree in the intrapleural tensions on one side of the thorax can be compensated for by a deviation of the mediastinum, and equal tensions again become established. Larger differences in the two sides compensate with greater difficulty depending on the resistance of the mediastinum.

SUMMARY

Comparison of the mediastinum in dog and man have shown that:

1. There is an essential difference in the mobility of the mediastinum in dog and man.

2. A comparison of the stability and strength of the structure reveals a marked difference in dog and man.

3. A change in the intrapleural tension of one pleural cavity produces a corresponding change on the opposite side but of different degree in the two instances. In man such a change is more or less compensated for by a deviation of the mediastinum. In the dog the mediastinum is not only freely mobile but also freely permeable to air and fluids, and equalization of the intrapleural tension occurs to a very exact degree.

4. Unilateral pneumothorax in the dog cannot be induced; bilateral pneumothorax uniformly results because of the permeability of the mediastinum.

5. Experimental results obtained in the dog with relation to surgical pneumothorax may not be applied to man without recognition of the difference in the structure of the mediastinum of dog and man.

6. Pneumothorax in man, if unilateral in origin, remains unilateral and the intrapleural tensions may or may not become equal on the two sides, depending on the resistance of the mediastinum and the initial differences in tension between the two sides.

7. It may be concluded that cohesion is probably not a factor in maintaining expansion of the lungs.

DISCUSSION

DR. J. J. SINGER, St. Louis: We seem to be up against a proposition. We have two sets of pictures by two laboratories, with two interpretations.

As an outsider, and as a man who has done a great deal of pneumothorax work in human beings, there are certain problems which present themselves to me irrespective of the question that seems to be a mooted one; namely, Is the dog a suitable animal for comparison in pneumothorax work with the human or not?

I am going to give you a few of the results of some observations we have noted that may have some bearing on the question, and it is possible that the essayist may help us a little in the discussion. Most men in doing pneumothorax work in tuberculosis, abscess and bronchiectasis, until Dr. Graham's work came out, assumed that if you had compressed one lung and compressed it solidly, the other lung became compensatory and to all intents and purposes did all the work; that the lung was compressed and did not function. And this was accepted by most men. That is the opinion I had until Dr. Graham came to Washington University. I was skeptical about his interpretation. He showed me experiments on the dog in his laboratory, and I was completely convinced that the lung was not collapsed in the sense we thought it was. The lung was much smaller when functioning. You could see the lung expand and contract with each respiration, so that we had to change our opinion as to whether we actually compressed the lung as we thought. Later, I showed roentgenograms in which the lung was almost down to the size of my fist around the hilum. To me that was convincing that some lungs do become completely collapsed. In studying the problem further, I have seen the roentgen ray deceive us on this problem. Other considerations must be taken into account, both pressure and the roentgen ray. In taking pressure, that is the only indication that has been used by both the essayists. If you put a needle in the chest, you get either positive or negative pressure of different degrees. When we take the pressure it has frequently happened that we get minus eight or six on the two phases of respiration, and we put in more air because we do not have positive pressure. We put the patient under the fluoroscope and we find we have not been compressing the lung at all, the lung being pushed and crowded into the right side of the chest, compressing the right lung; and compression in that degree I am sure must be going on in every case. It is only in those cases in which the mediastinum is very mobile that you get almost complete compression of both lungs and frequently death by asphyxiation, so that the needle itself is not the only thing to consider in passing judgment as to what is going on in the chest. With Dr. Allen and Dr. Graham, I have made some experiments with the thoracoscope fashioned after Jacobeus' method, and we were able to carry out air-tight pneumothorax

under direct supervision. We put the needle in the chest connected with a manometer, and with negative pressure introduced the air; and, through the opening in the chest, we could see the air compressing the lung, and could see the mediastinum, the pericardium, etc. I am sure you do not see the air, but you could see a change in pressure in the opposite pleural cavity, if there was a leak in the mediastinum. This did not happen. We have performed this experiment seven or eight times in working with the thoracoscope. As I saw these pictures these experiments came back to me. I have been told that there never has been a lung puncture of any kind for any purpose but that, if you look closely, you will find a pneumothorax resulting. Every time you do a thoracentesis, especially in animals in which the pleural space is small, you get into the lung tissue. In all of the plates except one that I have seen, in every one of the dogs there was a needle on both sides, and a tube introduced through the diaphragm. Until that picture was shown, I felt sure you were getting a double pneumothorax by puncturing the lung. The mediastinum was being held fixed by counter-pressure on both sides. It was not a shifting of the mediastinum in that condition.

It has been recognized today, in the use of the different gases for pneumothorax, that air is just as good as any other gas. Formerly, nitrogen was used, and oxygen and other gases also. Within twenty-four or thirty-six hours, analysis of the gas shows that it has become air. If there is a "leak" between the air we breathe and that which enters through the lungs through the diffusion of gases or nitrogen put into the pleural cavity, there is no reason why there cannot be a "leak" from the mediastinum. It may be a question of degree, but you do see pneumothorax on both sides. Whether the law of gases comes into play here I do not know.

Another important phase of the problem is that, when you puncture a lung and get pneumothorax in the dead dog, you have a different problem from that arising under similar conditions in the living dog. If in the animal or human being it were possible to keep the opposite lung distended, you would not get pneumothorax on both sides. I believe that you do get pneumothorax on both sides, but in the ordinary course of events in human beings and in dogs, a compensatory mechanism produces hyperactivity of the opposite lung, which expands against the chest wall and prevents the pneumothorax you have.

In pneumothorax it is a question whether it is better to experiment on the dog or on human beings and whether the findings are correlated or not. We have learned considerable by experiments on dogs, and I believe this work will help us in our work on human beings.

Dr. Carl A. Hedblom, Rochester, Minn.: This work was undertaken by Dr. Snyder at my suggestion, not because of any preconsidered convictions on our part but because of the divergent opinions expressed in the literature as to Dr. Graham's work.

Dr. Graham has done a great service by emphasizing that the danger of open pneumothorax in man is in direct relationship to vital capacity and the relative mobility of the mediastinum, a service which I am sure has resulted in the saving of a great many lives. The question of vital capacity is one which I am sure is absolutely fundamental to the subject. Given a very low vital capacity, a patient will stand an open pneumothorax badly, regardless of the condition of the mediastinum. With a mobile mediastinum such as must have been present in some patients I have operated on, the patient stands a large open pneumothorax badly regardless of the vital capacity. I am bound to say, however, that in other cases, in which the mediastinum was presumably normal, the patient endured a large

open pneumothorax without evidence of respiratory embarrassment. What variability there may be in the mobility of the normal mediastinum in man seems to me a matter for further study.

The particular question which Dr. Snyder's work raises is whether the mediastinum in the dog is sufficiently similar anatomically to the human mediastinum to warrant drawing conclusions as to the behavior of the human from that of the dog. His work was done in Dr. Mann's laboratory, and his observations were all carefully checked. If we accept his evidence, he has proved his point, it seems to me, that, for the purposes of the study of pneumothorax in man, the dog is not a suitable experimental animal.

Dr. Leon T. Le Wald, New York: We have recently seen bilateral pneumothorax occur spontaneously in the human. A young man, about 17, on roentgen-ray examination showed spontaneous pneumothorax on one side, the left. He did not care to enter the hospital, so we asked him to return the following day, when he had a pneumothorax (spontaneous) on the right side. The other side remained as before. I thought this a unique observation, but in speaking to some other roentgenologists, I found there were several cases on record. It looks as if the air had gone across the mediastinum.

Dr. Howard Lilienthal, New York: I understand that the mediastinum is a space and not a membrane or septum. When one speaks of the mediastinal membrane, one refers really to the combined right and left pleurae. Even in operating under local anesthesia, I have seen cases in which the to-and-fro motions were so violent that I feared rupture of the pleura. Elsberg, in his experimental work, noted the rupture of the mediastinum in dogs very frequently. In the human being, if air ever passes from one pleural cavity to the other, there should be also mediastinal emphysema, and even in dogs I do not see why air should enter the uninfected pleura without the occurrence of mediastinal emphysema. I trust that the question of the dog's pleural anatomy may soon be settled.

Dr. Edward W. Archibald, Montreal: A year and a half ago, I carried out a series of experiments to see whether paraffin oil might not be used to replace air in artificial pneumothorax as a means of compressing the lung. I operated on a dozen cats, one dog and one sheep, and introduced varying amounts of paraffin oil into one side. In the dozen cats, almost invariably the oil penetrated to the other side, in varying amounts, more or less in proportion to the amount I had put in. If I put in a large amount, a considerable amount would be found on the other side at necropsy. I could not determine in any case on the postmortem table just how the oil got through. That point in my information is lacking, because, although I dissected several animals, I had allowed a certain time to elapse between putting in the oil and performing the postmortem, and if it had penetrated by rupture or gross opening, that opening had again closed by adhesions. In the dog, the oil did not penetrate to the other side, nor did it in the goat and the sheep. So I felt that the cat was an unsuitable animal for these experiments. It seems to me, the problem can be solved only by exact dissection and further experimental work.

Dr. Lilienthal: What happened to the goat and sheep?

Dr. Archibald: The oil did not penetrate to the other side. It was introduced through a trocar in instalments; 300, 400, and 400 c.c. at intervals of several days.

I do not know that I understood Dr. Snyder quite clearly. As I understood, he said that he made measurements of pressure in the presence of pleural effusion

when there was no pneumothorax. I have constantly failed to get any pressure readings in the manometer when my needle was in fluid, both in these paraffin experiments and in one or two cases in human beings. I should like to have Dr. Snyder assure me on that point. I have given up trying to make measurements of the pressure when the chest is occupied partly by fluid and partly by air. In 1916, in two chest wounds encountered in the Army in which there was effusion of blood and a small pneumothorax on one side, I aspirated the blood and replaced it with oxygen under manometer pressure readings. I put a needle into the other side, also in the intact pleura, and registered the pressure simultaneously. On the side in which I had replaced a quantity of blood with air, I got a pressure of —264 cm. on expiration; on inspiration, — ten to twelve. On the sound side, the measurements were generally 2 cm. lower. I took it at the time that pressure was transmitted equally throughout the two sides of the chest cavity, 2 cm. being so small a difference as to be negligible; but in thinking it over later, I concluded that a difference of 2 cm. might have a definite significance. If you put air into one side of the chest, you may get no great difference in pressure measurements, but you do increase the tendency toward positive pressure in that side and perhaps disturb the balance between the two sides. Perhaps even a difference of 2 cm. toward positive pressure, as the result of air in one side of the chest, would have a definite influence in the dog in forcing air through a thin mediastinum and creating a pneumothorax on the other side also.

Dr. Conrad Georg, Jr., Ann Arbor, Mich.: I have seen what we call the mediastinum in dogs when I was operating to remove portions of the lung. It has an extensive opening on one side. I have seen it flutter violently, and it has almost ruptured through the large opening through which I was operating. It has impressed me that the mediastinum of a dog is a much thinner membrane than is that of the human. For instance, in the human being we often take large quantities of serous fluid from one side of the chest and find none in the other. Fluid in the human being does not permeate through it. In rabbits, if you open the chest and keep it open for hours, the animal shows no dyspnea; whereas, under similar conditions the dog shows marked dyspnea. The mediastinum in rabbits is not the same kind of membrane that it is in dogs.

Dr. Evarts A. Graham, St. Louis: This discussion has shown one thing if nothing else, and that is, that this whole thing is not a matter of conjecture. Conjecture will never settle this question any more than it has settled any question in the past. The whole thing is a matter of practical experimentation. A great deal of the confusion which occurs in the literature about this subject has been produced by those who rely on conjecture and have not resorted to the simple expedient of practical experimentation. Here we are confronted by two lines of experimentation which give absolutely conflicting results: Dr. Snyder's, on the one hand, and mine, on the other. Dr. Snyder says that it is impossible to produce unilateral pneumothorax in the dog. Nevertheless, as my lantern slides this morning showed, I have repeatedly produced a unilateral pneumothorax in the dog. The question is, therefore, merely a matter of practical experimentation. Either he is wrong or I am wrong, and both of us should get busy and thresh out this matter. This is, to my mind, perhaps the most fundamental question in thoracic surgery at the present time. The future of thoracic surgery is going to depend largely on these matters of fundamental physiology; and, in connection with these problems, nothing is more important

than the question as to what happens when a pneumothorax is created. This Association should be vitally interested in this question, and it is this organization that should settle it.

It is absolutely impossible for me to get any sort of an explanation of Dr. Snyder's results because they are at such complete variance with my own observations. I have seen unilateral pneumothorax repeatedly in dogs. If I have seen it once, I have seen it a hundred times, because I have made a great many thoracic experiments. If there were a free communication between the two pleural cavities of the dog, then obviously the mediastinal structures should not be displaced when air is admitted into one pleural cavity. But, experimentally, it is a simple matter to see that they are displaced, and if a large opening is made into one pleural cavity the to-and-fro movement of the mediastinal pleura is often so violent as to cause its rupture. In many instances, the act of expiration pushes it clear out of the opening before rupture occurs. This could not occur if Dr. Snyder's views were correct.

A point which to many seems difficult to understand is why, in a unilateral pneumothorax, the lung on that side should be so much smaller and appear to be as much more compressed than the other lung if the two intrapleural pressures are nearly the same. One possible explanation of this is to be found in the action of the elastic tissue of the lung. When the lung is pushed away from the chest well by the air, the elastic fibers are permitted freely to contract, because the former adhesion of the lung to the chest wall no longer exists. This would result in a greater compression of the lung on that side than on the other, even if the two intrapleural pressures were nearly the same.

There are those, of course, who would like to substantiate Dr. Snyder's results. There are many others, some of whom I quoted, who would substantiate the results I have brought forth: again a difference in observation. The one point I would challenge is the statement that you cannot make a unilateral pneumothorax in a dog, and I can challenge that statement successfully from the roentgen-ray plates I have shown. I challenge it again successfully on the ground that I have shown by many observations in repeated instances that you get a difference in pressure in the two sides when you measure the pressure by the manometer. I cannot see how one can reconcile that with a communication between the two pleural cavities.

The experiments on human cadavers which Dr. Snyder mentioned were of great interest to me. It is unfortunate that Dr. Snyder did not mention whether or not these cadavers had been chilled, because, as I emphasized this morning, chilling is of the greatest importance. He said in one case the cadaver was 3 hours old. That is too long after death to carry on an experiment of this kind accurately. Doubtless, rigor mortis had already set in. Possibly also, the body had been embalmed. The mediastinal pleura, both of the human and of the dog, becomes much more rigid if chilling has occurred. Doubtless also, embalming fluid would have the same effect. To get accurate results, we must work with a body that is still warm; immediately after death, if possible.

Dr. Yates brought out the very important point that this problem should not be settled by experimentation on the dead, and that we must not lose sight of the fact that the living body is concerned in it. Experiments have been conducted on the living human being with this very point of view. I have not done any work myself in the measurement of pressures on the living human, but Dr. Simon, whom I quoted, has made such experiments. He finds a very slight difference in the pressure readings of the two pleural cavities in the human being when the pressure is changed on one side by the introduction of

air. Negative experiments are not so significant nor of so much consequence as positive experiments, because in the negative experiments it is difficult to rule out questions of pathology, which may alter conditions. For example, adhesions, induration of the mediastinum and other conditions may be present to vitiate the changes which one might expect in a normal condition. For the same reason, I should say the experiments which Dr. Snyder performed on patients with bilateral effusion had nothing to do with the case we are discussing. A patient with an effusion in the chest has not a normal thorax. He has an edematous pleura which is more rigid, much less flexible, than a normal pleura. The experiments made on patients with bilateral effusion had nothing to do with the case. We were talking about normal thoraces.

A point was made by Dr. Georg of Ann Arbor that, in the human being, we usually find a purulent effusion limited to one side, and not extending over into the other side, and I supposed what he meant was that this factor in the human being was different from that in the dog. I have had occasion to produce purulent effusions in a considerable number of dogs in various ways. I have produced them by the injection of bacteria. I have produced them also by direct injection of empyemic fluid. In an occasional dog, I have found an effusion on the other side as well as on the injected side. When one injects virulent hemolytic streptococci into one pleural cavity, one often gets a large pleural effusion on that side, and maybe, twenty-four or thirty-six hours later, a smaller pleural effusion in the other pleural cavity. In connection with that, the dog will have also a pericardial effusion, and the process is really one of direct inflammatory extension rather than one of direct passage of fluid from one side to the other, because you do not get it right away. It takes thirty-six hours to develop, and difference in quantity is very marked. The amount of pleurisy is much less than on the side injected. The fact comes up again that we are dealing with an inflamed pleura and any stomas or other openings which might be present would be sealed by the edema or inflammation. I merely mention this point because it was raised by Dr. Georg.

In regard to the remarks of Dr. Lilienthal concerning mediastinal membrane, what I meant was the mediastinal partition between the sternum and the pericardium. This partition consists of two layers of pleura with a little fat between. This fat is variable. In obese subjects, there may be a great deal, and in emaciated subjects, practically none. Even in the human being, this mediastinal partition is often so thin that it resembles a soap bubble, just as in the dog. If you do not believe it, examine a series of cadavers, making an incision on one side so that you can see. Do not make the usual incision of the pathologist. Most pathologists do not see the mediastinal membrane when they perform a necropsy. Many pathologists do not have any conception how thin this mediastinal partition is in the human being.

With regard to Dr. Archibald's statement, he spoke about a difference of 2 cm. in pressure between the two sides in a case of a wound of the chest. A difference of 2 cm. is about what is to be expected with pressure such as, I think, he might have had.

Dr. Yates spoke of two points in his discussion. He dwelt particularly on the point that we should get at the living pathology. Nothing can be truer than that, but I think a great deal of the experimental evidence produced is living physiology, and when I touched on the theoretical aspects of the vital capacity, it seemed to me that is certainly living physiology, if nothing else. Vital capacity is a function of life. There is no vital capacity in a dead person, and we are talking about vital capacity in the living. Many of these experiments were made on the living, and not entirely on the dead.

In regard to the point in reference to the circulation which Dr. Yates brought out, it is one of great importance which is often overlooked, and I think Dr. Yates deserves great credit for emphasizing it as he did this morning and in his article published last January. I do not think, however, that it is a new point. Everybody is familiar with the fact that when you have asphyxia you have a rise in blood pressure; that enables more blood to pass through the arteries. Therefore, when you have partial asphyxia or fatal asphyxia, the blood pressure goes up, and you may have increased pressure demonstrable in the lungs. Again, he mentions the fact that the function of the heart is the important conpensatory mechanism. It does not make much difference whether one speaks of the function of the heart or the function of something else in reference to this particular question, because again failure of the heart to function properly will usually be shown by a determination of the vital capacity. It is well known that in decompensated cardiac cases there is a low vital capacity. Such is the case also with nephritis, with acidosis, with acute febrile conditions or with any impairment of the respiratory muscles or impairment of the actual air capacity of the lungs. There are many things which will influence the vital capacity. In conclusion, it seems to me that while interference with the circulation is an important thing, it is not the fundamental thing. Disturbance of the circulation is secondary and really follows a disturbance of the respiration, and the resulting disturbance in the aeration of the blood which follows.

Finally, one other point: Dr. Meyer, in his discussion of my paper, said that he thought the thing which I was really trying to get at was an estimation of how large an opening could be made in the chest wall in any given case. I was very particular to say that that is not my object in this work. That was purely incidental to the general idea I was developing. It is not a question of whether the maximum nonfatal opening is 60 or of 160 square cm. There will be all sorts of differences in different individuals. The only thing I am interested in is to show the etiologic relationship that exists between the vital capacity and the amount of damage which can be done through the pleural opening, and it will always be an approximate thing. It will never be absolutely accurate, because there are too many factors that come into play.

Dr. J. W. Snyder, Rochester, Minn.: With regard to Dr. Archibald's question concerning pressure determinations in pleural effusions, we have made such determinations in a series of cases, and while in accuracy they were not at all comparable with the measurements of pressures in pneumothorax, still they gave us a general indication of what was happening. In effusions, the respiratory oscillations of the manometer are dampened because of the inertia of the fluid while passing through the needle. It is advisable to prevent fluid entering the tube leading to the manometer and if this does occur it should be emptied before taking a reading.

In regard to the mediastinum, if you will open one pleural cavity in the dog well on the side of the chest, taking care to preserve the mediastinum intact, and then proceed to pump air into the unopened pleural cavity, you will produce a bulging of the anterior mediastinum. The heart and other mediastinal structures are freely mobile; but with the bulging of the anterior mediastinum, the heart will not be displaced more than 1 cm. Almost as soon as the pumping is stopped, the mediastinum will drop back into its normal position. Under these conditions, the pressures obtainable within the unopened pleural cavity have never exceeded 0.5 cm. of water. To us, this would indicate that air passes readily through the mediastinum of the dog.

If both pleural cavities are opened in a dog and a moderate amount of fluid is placed in one pleural cavity by turning the animal to the opposite side, the fluid is brought in contact with the anterior mediastinum, and it will pass through in a stream. This can occur with amounts as small as 50 c.c.

Another point: When one is operating on a dog under differential pressure and has opened one pleural cavity widely, the mediastinum moves but little, and there is no violent movement with respiration. The anterior mediastinum is so thin that it tears with the lightest touch.

In regard to cadavers, we have recognized the importance of doing this work as soon as possible after death. In no case were we able to make determinations sooner than one-half hour after death, while the majority were made at about one hour after death. In most cases, the body was still warm, although rigor mortis was frequently present.

GRADED EXTRAPLEURAL THORACOPLASTY IN THE TREATMENT OF DIFFUSE UNILATERAL BRONCHIECTASIS *

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Pathologically, bronchiectasis presents inflammatory dilatation and narrowing of the bronchi. Clinically, it is recognized chiefly by the presence of chronic cough and more or less characteristic, abundant sputum, and by the exclusion of purulent bronchitis, pulmonary tuberculosis, pulmonary abscess and empyema with bronchial fistulas. Bronchiectasis is essentially the result of infection of the bronchi, such as may be produced by any one of the chronic lung affections intrinsic or extrinsic to the bronchi. It may occur, therefore, as a complication of any one of the above mentioned conditions. Secondary abscess formation also occurs from ulcerative perforation of the bronchial walls.

The diagnosis, which presents no especial difficulties, is based on the history, clinical aspects of the case, and roentgen-ray and laboratory examinations. Chronic abscess of the multilocular type and multiple small scattered abscesses are sometimes differentiated with difficulty. Generally speaking, the symptoms and signs characteristic of infection are more marked in cases of chronic abscess, and there is often a history of repeated exacerbations of fever, leukocytosis and abrupt fluctuation in the amount and character of the sputum.

If the roentgenogram reveals approximately normal translucency and the physical signs are slight, a definite diagnosis of uncomplicated bronchiectasis may usually be made. Cases occur, however, in which there is a dense, more or less uniform shadow on the plate, and in which the physical signs are not localized. Differentiation of abscess and bronchiectasis may then be impossible.

EXTENT OF INVOLVEMENT

Uncomplicated bronchiectasis may be localized or diffuse, unilateral or bilateral. It may be difficult to determine the extent of involvement in any given case by physical and roentgen-ray examinations. I have observed a patient who expectorated approximately 1,100 c.c. of sputum a day, and by neither method of examination could it be determined from which side the pus came. The question was settled only after repeated bronchoscopy. Definitely localized bronchiectasis may give a characteristic sharply defined shadow in the roentgenogram.

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TREATMENT

The principles involved in the surgical treatment of pulmonary suppuration are drainage, collapse of the lung and extirpation of the diseased tissue. In attempting to evaluate the relative merits of these procedures, theoretical considerations, as in experimental investigations, must give way to the crucial test. The results of any method have not been brilliant. It has been said that the surgical treatment of bronchiectasis is the most thankless task in surgery.

Drainage.—A consideration of the pathologic anatomy in cases of typical diffuse bronchiectasis would seem sufficient to demonstrate on *a priori* grounds the futility of attempting surgical drainage, for the simple reason that drainage of all portions of the diseased bronchial tree cannot be effected. In localized saccular bronchiectasis, on the other hand, there may be drainage sufficient to produce at least marked improvement, as long as drainage is maintained. Probably, a large proportion of cases in which cure or benefit is reported are of this type. Not only has surgical drainage often failed, but it has been attended by a high mortality. Batzdorff,[1] in a series of fifty-three collected cases, reported 9.4 per cent. of the patients cured; 6 per cent. improved, and a 62 per cent. mortality. Sauerbruch[2] collected 123 cases, in which 33 per cent. of the patients were cured; 27 per cent. were not improved, and 23 per cent. died. In individual series, in which unfavorable results are more likely to be included, the mortality is even higher.

Thirty-seven per cent. of Garrè's[3] patients died immediately after operation, and 78.6 per cent. of Körte's.[4] In two of my cases of localized saccular bronchiectasis, drainage was followed by improvement, but not cure.

Pneumectomy.—From the standpoint of pathologic anatomy, pneumectomy would seem to be the operation of choice in cases of bronchiectasis, but the proportion of cures has been small, and the operative mortality high. Willy Meyer,[5] in 1914, wrote that, up to that time, there had been sixteen lobectomies, with eight deaths. In 1915, he reported the case of another patient on whom he operated successfully.

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1. Batzdorff, E.: Die chirurgische Behandlung der Bronchiektasie, Centralbl. f. d. Grenzgeb. d. Med. u. Chir. **16**:1-18, 1913.

2. Sauerbruch, F.: Die Chirurgie der Brustorgane, Vol. 1, Berlin, Julius Springer, 1920.

3. Garrè: Die chirurgische Behandlung der Lungenkrankheiten, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **9**:322-337, 1902.

4. Körte, W.: Erfahrungen über Operation wegen Lungen-Eiterung und Gangran, Arch. f. klin. Chir. **85**:1-62, 1908.

5. Meyer, Willy: On Bronchiectasis, Tr. Am. Surg. Assn. **32**:592-618, 1914.

Robinson,[6] in 1917, reported seven cases, with three deaths. Hitzrot [7] reported one operative recovery. Hansen [8] had four cases, with one death. Sauerbruch [2] performed single stage lobectomy on three patients, all of whom died, and on six patients following pulmonary plastic operation (with ligation of the pulmonary artery) without a death. Lilienthal [9] reports twenty-one cases; twelve patients died, seven recovered, one still coughed and expectorated and one was convalescent. Graham [10] adds three cases, with one cure. In a total of sixty-two cases, there was, therefore, a combined mortality of 46.7 per cent. According to Graham, there were only 17 per cent. of cures in forty-eight cases studied by him.

Even considering the brilliant results obtained in a small proportion of cases in this most difficult field of surgery, it would seem open to question whether an operation that carries so high a mortality and so low a proportion of cures is justified by its results. The question may also be raised whether some of these cases diagnosed as bronchiectatic abscess were not of the type ordinarily known as acute posttonsillectomy abscess, for which operative drainage has yielded a high percentage of cures and a relatively low mortality. The indications for lobectomy, moreover, in the estimation of its most enthusiastic advocates, have been limited to young adults in good general condition, in whom the other vital organs are not damaged. This leaves a large number of patients for whom other operative measures must be adopted if they are not to be left to their fates.

Extrapleural Thoracoplasty.—Of the other methods of treatment, thoracoplasty would seem to offer the most hope. The rationale of extensive rib resection for the purpose of collapsing the lung in case of large pulmonary cavitation was first pointed out by Quincke,[11] in 1888. He insisted that inflammatory thickening of the walls of the abscess, and adhesions to the parietal pleura prevented the collapse and healing

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6. Robinson, Samuel: The Resection of Lobes of the Lung, J. A. M. A. **69**:355-358 (Aug. 4) 1917.

7. Hitzrot, J. M.: Lobectomy for Bronchiectasis, Ann. Surg. **71**:785-787, 1920.

8. Hansen, P. N.: The Surgical Treatment of Bronchiectasis (Report of Four Cases of Bronchiectatic Cavities Treated by Lung-Lobe Resection), Nord. med. Ark. **1**:1-24, 1917.

9. Lilienthal, H.: Resection of the Lung for Suppurative Infections, with a Report Based on Thirty-One Operative Cases in Which Resection Was Done or Intended, Ann. Surg. **75**:257-320 (March) 1922.

10. Graham, E. A.: The Surgical Treatment of Bronchiectasis, with a Report of Three Cases of Removal of a Lobe of the Lung, Arch. Surg. **6**:321-336 (Jan.) Part 2, 1923.

11. Quincke, H.: Zur operativen Behandlung der Lungenabscesse, Berl. klin. Wchnschr. **25**:349-352, 1888.

of the cavity. Spengler,[12] two years later, independently advocated the same principle. He observed that cicatricial contraction of the healing tuberculous lung manifests itself by the retraction of the surrounding structures; that is, the heart, mediastinum and diaphragm, toward the affected side. The effect of cicatricial contraction on the conformity of the chest wall is often observed to result in deepening of the supraclavicular and infraclavicular fossae; marked structural changes in the ribs, and even scoliosis of the vertebral column. Spengler reasoned that plastic rib resection, in such cases, would promote cicatricial contraction and healing. In 1896, Quincke [13] again urged thoracoplasty on the grounds that collapsing the lung, thus putting it at rest, would lessen blood and lymph circulation, and thereby tend to arrest the process of cavity formation. In spite of these suggestive observations and some measure of success obtained by Turban [14] and by Landerer [15] in a few cases, the method was not given serious consideration nor really put to the test. It was only after the adoption of artificial pneumothorax in the treatment of pulmonary tuberculosis that thoracoplasty was again considered in tuberculous cases, in which adhesions prevented artificial pneumothorax. Brauer [16] pointed out that failure to obtain a larger measure of success in the earlier cases was due to failure to carry out the requirements of a sound principle. Friedrich [17] was the first to put the method to a real test by an operation sufficiently extensive for complete collapse of the chest wall over the diseased lung. His operation, which involves resection of the entire length of the first ten ribs in one stage, is a formidable procedure, and a high mortality is to be expected, even in patients who are fairly good surgical risks. By dividing the operation into stages, Wilms [18] lowered the operative risk and thereby extended the indications for thoracoplasty.

On the Continent, thoracoplasty has been applied in large series of cases of unilateral tuberculosis, with gratifying results. In 1921, Sauerbruch reported 294 cases of pulmonary tuberculosis, in which operation was performed, chiefly by his own method and by the method

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12. Spengler, K.: Quoted by Sauerbruch (Footnote 2), p. 706.

13. Quincke, H.: Ueber Pneumotomie, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **1**:1-70, 1896.

14. Turban, K.: Zur chirurgischen Behandlung der Lungentuberkulose, Berl. klin. Wchnschr. **36**:458-459, 1899.

15. Landerer, A.: Die operative Behandlung der Lungentuberkulose, München. med. Wchnschr. **49**:1948-1952, 1902.

16. Brauer, L.: Respirationskrankheiten, Jahresb. f. Harztl. Fortbild., No. 2, p. 44-102, 1910.

17. Friedrich, P. L.: Die Chirurgie der Lungen, Verhandl. d. deutsch. Gesellsch. f. Chir. **2**:52-82, 1907.

18. Wilms: Eine neue Methode zur Verengerung des Thorax bei Lungentuberkulose, München. med. Wchnschr. **58**:777, 1911.

of Brauer and Friedrich,[19] and about 60 per cent. improvement or cure resulted. The method has not as yet been generally adopted in this country, but is growing in favor.

The analogy between certain forms of nontuberculous suppurative cavities and cavities of tuberculous origin secondarily infected with the same type of pyogenic organisms seems striking. It would seem that, if healing of secondarily infected tuberculous cavities can be furthered by collapsing their walls, healing of nontuberculous cavities should be made more certain by employment of the same method.

Opinions expressed in the literature with regard to results of thoracoplasty for nontuberculous pulmonary suppuration have varied greatly. Brauer is quoted to the effect that he has neither observed, nor seen reported in the literature, a genuine case of pulmonary suppuration of bronchiectasis really healed by collapse. Hansen tried the method in two cases, without benefit. DeQuervain performed lobectomy in one case following thoracoplasty. Mumford[20] and Robinson lost two patients, and nearly lost a third, following this operation. Many cases of marked improvement and some cures have also been reported. Lenhartz[21] reported two cases of extensive resection in which one patient was cured and the other improved. Küttner[22] treated one patient, whose symptoms had not recurred seven months after operation. Luxembourg[23] reported a cure following Friedrich's operation, combined with apical pleurolysis and resection of the clavicle. Three of Lilienthal's[24] patients improved, and one died. Davies[25] performed a Wilms' operation in one case. The patient's condition improved greatly; cough and sputum diminished, and the sputum was no longer offensive. Zinn and Muhsam[26] reported a case in which decided improvement

19. Brauer and Friedrich: Ueber Lungenchirurgie, Verhandl. d. Gesellsch. Naturf. u. Aerzte, Part 2, No. 2, p. 166-186, 1909.

20. Mumford, J. G., and Robinson, S.: The Surgical Aspects of Bronchiectasis, Tr. Am. Surg. Ass'n **32**:688-696, 1914.

21. Lenhartz, H.: Zur operativen Behandlung des Lungenbrandes, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **9**:338-360, 1902.

22. Küttner, H.: Diffuse Bronchiektasien und grosse bronchiektatische Kaverne. Pneumolyse. Ausgedehnte Thoraxresektion in der Unterdruckkammer. Vollkommene Heilung, Beitr. z. klin. Chir. **60**:29-32, 1908.

23. Luxembourg, H.: Ein Beitrag zur Behandlung von Bronchiektasien mittels extrapleuraler Thorakoplastik, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **21**:637-646, 1910.

24. Lilienthal, H.: Pulmonary Abscess and Bronchiectasis, Ann. Surg. **59**:855-883, 1914.

25. Davies, H. M.: Bronchiectasis Treated by Rib Mobilization (Wilms), Proc. Roy. Soc. Med. Clin. Sect. **8**:33-34, 1915.

26. Zinn, W., and Muhsam, R.: Ueber extrapleurale Thorakoplastik bei Lungentuberkulose und Bronchiektasien, Berl. klin. Wchnschr. **52**:45-49, 71-75, 1915.

followed operation. Körte carried out extensive rib resections in three cases. One of the patients died of brain abscess; the results were uncertain in one, and one was completely cured. Sauerbruch reported twenty-seven cases. Five patients were permanently benefited; one obtained only temporary improvement; one died, and one became worse after a year. In eleven patients with postpneumonia complications, there was enduring benefit, characterized by diminution in sputum, disappearance of putrid stench and improvement in the general condition. The imperfect results reported were probably due in part to a failure to perform an operation sufficiently extensive to secure complete collapse, and in part to operating too extensively at one stage. In the latter instance, a high operative mortality may be expected, because of shock, embarrassed respiration and retained secretions. A graded thoracoplasty may be divided into a number of stages, the shock being thus minimized and the patient allowed to adapt himself by degrees to the disturbance to respiration and circulation. Extensive resection can be accomplished eventually, and the indication for operation can be extended by making it less hazardous. Experience has shown that certain patients thus treated will improve so much that an approximate cure is obtained, and the dangers of the more radical operation are avoided. If the results are unsatisfactory, lobectomy can then be performed, probably with the minimum of operative risk.

TECHNIC OF OPERATION

The day before operation, the patient is instructed to empty the secretion from his bronchial tract as thoroughly as possible, by assuming an inverted position across the bed with his head near the floor. At intervals of half an hour, beginning two hours before operation, he is given, subcutaneously, one-eighth grain of morphin sulphate in 2 c.c. of a 25 per cent. magnesium sulphate solution. The operation is performed under combined regional and nitrous oxid and oxygen anesthesia, enough nitrous oxid and oxygen being used to produce a condition which Crile designates as analgesia. In my experience, such combined anesthesia has been uniformly effective and satisfactory. The anesthesia is of special importance in graded operations of this kind. A painful first operation will undermine the patient's morale for succeeding operations.

A posterior resection is performed through a straight paravertebral incision, in two or three stages. The upper ribs are the least accessible, on account of the heavy muscles, but it is quite feasible to resect all the ribs, including the first, by this approach, without any risk to the large blood vessels which lie anteriorly. The ribs are resected subperiosteally, segments from 6 to 12 cm. long being removed according to the exposure obtained. After resection, the nerve trunks are each

injected with a few drops of absolute alcohol. This reduces and often entirely prevents postoperative pain. The sternal ends of the ribs are then resected in one or two stages. Local anesthesia for the removal of the distal and medial segments is much simplified by the earlier alcohol injection, the anesthetic effect of which persists for some time. The medial segments are the most inaccessible in the portion lying under the scapula. These segments may be removed in two stages. First, the lower segments are removed through a straight intercostal or a T incision, and later the upper segments through a tongue-shaped incision, a continuation of the straight incision, encircling the lower angle of the scapula. At the end of each operation, the wound is closed in layers, care being exercised to approximate the cut edges of the successive layers of muscles. Usually, a drain is inserted, and is removed in from twenty-four to forty-eight hours. After the operation, the patient is assisted to assume a head-down position across the bed several times a day, in order thoroughly to evacuate secretions. There is usually very little pain incident to this procedure. The patient sits up as early as he feels disposed, often the second or third day.

REPORT OF CASES

CASE 1.—*History.*—A student, aged 19, presented himself at the Mayo Clinic in May, 1920, complaining of cough with excessive foul sputum, and extreme weakness. The onset of illness occurred in March, 1918, when the patient began to have an unproductive cough and felt sick, but was not confined to bed. The cough increased in severity, but remained unproductive. About three months after the onset, a diagnosis of pleurisy with effusion was made, and a rib was resected for drainage. Drainage tubes were removed in three weeks and the wound closed promptly. A second drainage operation was necessary, and the wound again healed promptly. About four weeks later, the patient began to raise foul, purulent sputum; the breath became foul, and he became very weak. Cough persisted, aggravated by exertion or change in position, especially by lying on the left side. The sputum increased from 240 to 500 c.c. in twenty-four hours.

Examination.—The patient was anemic, emaciated and very weak. The fingers and toes were clubbed, cold and cyanosed. The teeth were carious and the gums markedly pyorrhetic. There was a purulent nasal discharge, probably because the purulent sputum was evacuated through mouth and nose. The sinuses of the head were reported normal. The thorax was resonant and the breath sounds were amphoric. Litten's sign was present on both sides. The blood pressure was 104 systolic, 60 diastolic; the pulse 80, and the leukocytes varied from normal to 18,000. The sputum did not contain tuberculosis bacilli, and elastic tissue was found on one examination only. Roentgenograms revealed marked bronchial infiltration at the right base. The diagnosis was bronchiectasis of the right lower lobe, secondary to an old healed empyema with bronchial fistulas.

Operation and Course.—No improvement followed several weeks of expectant treatment, and extrapleural collapse of the chest wall was effected by a five-stage operation with removal of practically the whole length of the third to

the eighth ribs. There were no postoperative complications, and the patient's general condition improved markedly. At times, he was free from sputum; at other times, the amount was about half what it had been before operation. In September, 1922, he returned to the clinic for further consideration. The physical findings and the roentgenograms indicated an imperfect collapse and persistent cavitation of the base of the right lung. Practically the whole length of the ninth, tenth, and eleventh ribs was then resected. Two days later, the patient volunteered the information that he could now raise sputum with much greater ease. During the last weeks he was under observation, he was raising less than 1 ounce (30 c.c.) a day, and was gaining in weight and strength.

CASE 2.—*History.*—A laboring man, aged 28, presented himself at the Mayo Clinic, Nov. 1, 1920, with a history of having had a cough with profuse foul expectoration as long as he could remember. There was no family history of tuberculosis. The cough became more persistent after an attack of influenza in the autumn of 1918. It was brought on by changes in position, particularly to the recumbent; was paroxysmal, and was accompanied by the evacuation of from 500 to 1,000 c.c. of thick, occasionally blood-tinged, purulent sputum, then freedom from cough for several hours. Recently, there had been slight fever after hard work.

Examination.—The patient appeared to be in fair physical condition. The thorax was hyperresonant throughout except for the right base, where there were signs of fluid, which disappeared after the evacuation of pus. On bending over, the patient promptly brought up a large amount of foul smelling pus. The fingers were clubbed and the nails curved. A roentgenogram revealed bronchiectasis involving the right lower lobe. The tonsils were septic. There was moderate arteriosclerosis. The blood pressure was 120 systolic, 58 diastolic. Tuberculosis bacilli were not found in the sputum. The leukocytes numbered 5,600. A diagnosis was made of right bronchiectasis, and a thoracoplasty, to be followed by lobectomy if symptoms persisted, was advised.

Operation and Course.—A two-stage resection of the fourth to the tenth ribs from their angles to the costochondral juncture was performed, under combined nerve trunk and local anesthesia. The pleura was of normal thinness. There were no complications. Following these operations, the amount of sputum dropped from about 600 c.c. to from 30 to 60 c.c. during twenty-four hours.

Feb. 28, 1921, the patient returned for examination. He had gained 12 pounds (5.45 kg.), and had at no time raised more than from 30 to 90 c.c. of sputum. Roentgenograms at this time revealed incomplete collapse due to the posterior stumps having been left too long. The third to the seventh residual stumps were resected, and regenerated fragments of rib extending forward from them were removed, and about 5 cm. of the second rib. The patient recovered from the operation without complications. In more than two years that have elapsed since the last operation, the patient has been relatively free from cough, raising on the average from 30 to 75 c.c., and never more than 90 c.c. of sputum in twenty-four hours. The sputum is sometimes foul, but not so foul as before operation. About a year after the last operation, he had a little hemoptysis for a few weeks, which then entirely subsided. He has gained in weight and his general condition is good.

CASE 3.—*History*—A girl, aged 12 years, came to the clinic in December, 1919, with a history of good health, except for pertussis at the age of 3, and pneumonia at the age of 6, until December, 1918, when she had influenza fol-

lowed by a cough which persisted throughout the year, disturbing her sleep. Expectoration was foul and blood streaked, and was especially abundant in the morning, amounting to from 300 to 500 c.c. in twenty-four hours. There had been a loss of 9 pounds (4 kg.) during the year.

Examination.—Signs of cavitation were found over the left lower lobe after the cavities had been emptied of pus. Râles were heard above this area. The tonsils were infected. The sinuses appeared normal. The sputum, about 300 c.c. in amount, was thick and purulent. No tuberculosis bacilli or elastic tissue fibers were found in it. The leukocytes numbered 11,800. A roentgenogram revealed bronchiectasis of the left lower lobe.

Treatment and Course.—Owing to the patient's youth, artificial pneumothorax was first tried. There was marked improvement in her general condition. There was a gain of 7 pounds (3.2 kg.) in three weeks; and the sputum decreased to from 60 to 90 c.c. in a twenty-four-hour period. The patient was dismissed from observation, to return if symptoms recurred.

She returned seven months later. The cough and the expectoration had been less for three months, when, after chills and fever, it returned. The sputum had increased in amount, and the patient had lost 10 pounds (4.5 kg.). The condition was the same as at the first examination.

Operation.—Since exacerbation of cough and sputum seemed to follow attacks of sore throat, tonsillectomy was performed, and the patient was again sent home. Two months later, she had not improved, and again returned. A thoracoplasty was performed in four stages under local and nitrous oxid anesthesia, with resection of practically the whole length of the fifth to the eleventh ribs. Following the last operation, a serosanguineous effusion collected under the skin muscle flap, which was evacuated, with relief of dyspnea and cyanosis. A small amount of sterile pleural effusion was also aspirated.

Outcome.—The patient was dismissed from the clinic in February, 1922, in excellent condition. She raised from 15 to 30 c.c. of mucoid sputum in the morning, but otherwise she was symptom free. Her father said that her sleep was uninterrupted by cough for the first time since the onset of her illness. Two months later, she had gained 15 pounds (6.8 kg.); had practically no cough, and raised only a few cubic centimeters of sputum in twenty-four hours. There had been no return of symptoms and no disability from the operation. The patient had attended school during the last year, and had gained in all 30 pounds (13.6 kg.).

Case 4.—*History.*—A woman, aged 32, came to the clinic, Jan. 13, 1922, because of recurrent attacks of cough, and abundant foul, purulent sputum. Except for several attacks of rheumatism since the age of 18 and pneumonia at the age of 25, she had been in good health. The onset of the present illness followed tonsillectomy under local anesthesia in September, 1918. Six weeks later, she had an attack of pain in the left side; the breath became foul, and, for four months, she coughed up large amounts of very foul sputum. Following the birth of a baby, she was in excellent health for eighteen months, coughing and raising only a little. There had been three distinct attacks since, lasting from a few weeks to three months, with periods of remission, but the cough had been persistent and the sputum foul and abundant during the five months immediately preceding her visit to the clinic.

Examination.—The patient was in fair physical condition. There was slight dulness to percussion in the region of the lower angle of the right scapula, when râles were heard. An anteroposterior roentgenogram did not reveal a

lesion, but one taken in the oblique direction revealed marked infiltration around the lower left bronchus. The blood pressure was 128 systolic, 86 diastolic. The sputum varied from 120 to 500 c.c. during twenty-four hours. The diagnosis was unilateral bronchiectasis involving the left lower lobe.

Operation and Course.—A subperiosteal resection of practically the whole length of the fourth to the eleventh ribs was effected in five steps, under combined local and nitrous oxid anesthesia. The nerve trunks were injected with quinin and urea hydrochlorid solution, to minimize postoperative pain. Eight days after the last operation, the patient had a sudden elevation of temperature, which persisted four days. She then complained of pain in the shoulder. The general condition improved, but she continued to cough up a large amount of sputum, up to the time of dismissal. One month after she returned home, her husband reported that she had improved remarkably, the cough and sputum were greatly decreased, and the general condition was excellent. Her health had remained good, but at times she had pain in the chest, and coughed and raised a variable amount of sputum; less, however, than before operation.

CASE 5.—*History.*—A boy, aged 14 years, who first came to the clinic in December, 1919, had dyspnea and a morning cough with expectoration of large amounts of foul-smelling sputum every two or three days. The onset of symptoms had followed appendectomy.

Examination.—There was dulness to percussion at the left base, with tubular breathing anteriorly. The fingers were clubbed. The roentgenogram was suggestive of fluid, but it was not found on aspiration. Creosote inhalations were recommended. In June, 1920, the patient returned for examination. Cough with foul sputum and dyspnea were still present, and there were signs of consolidation at the left base, but the general condition seemed distinctly improved. In March, 1922, he was again examined. He still had coughing spells nearly every morning, and brought up foul, yellowish green sputum. There was still dulness at the base of the lung, posteriorly, with diminished breath sounds and dulness and tubular breathing in front. The sputum did not contain tuberculosis bacilli. Roentgenograms revealed dense infiltration from the hilum outward. The heart was drawn to the left. The diagnosis lay between old abscess and bronchiectasis, the fair general health rather pointing to bronchiectasis.

Operation and Course.—An extensive extrapleural collapse was effected by the resection of the whole length of the third to the eleventh ribs subperiosteally, in six stages. The first operation was performed, April 3, and the last, June 9. The patient was usually up and around the second or third day, and began gaining from 3 to 4 pounds (85 to 113 gm.) a week after completion of the plastic collapse. He coughed up 60 to 90 c.c. of purulent sputum. After being dismissed from the hospital, July 2, he continued to cough and raise considerable foul purulent sputum.

In November, 1922, he returned for observation. The upper lobe was extensively filled with cavitations. A month later, he developed an abscess in the chest wall, which was drained and several hundred cubic centimeters of pus evacuated. At this time, there was little cough. In April, 1922, the patient was up and around, but had slight fever, cavity signs at the left apex and a little dulness at the bases. Pleural effusion was ruled out by exploratory aspiration. The sputum for twenty-four hours averaged from 60 to 90 c.c. The pus from other abscesses in the chest wall was later found to contain actinomycosis organisms.

Case 6.—*History.*—A girl, aged 18 years, came to the clinic, July 19, 1920, on account of a chronic cough with sputum, which she had had as long as she could remember, at least for nine years. She usually had three coughing spells a day, but they were brought on at any time if she lay on her back, or with head down. She had had five attacks of pneumonia. After the last attack, five or six years before, her health had improved remarkably and her weight had doubled. The cough persisted, and the sputum reached from 360 to 480 c.c. in twenty-four hours.

Examination.—Dulness, friction sounds and râles were noted over the left lung, chiefly in the lower posterior portion. The fingers were clubbed. The tonsils were septic, and there was a chronic left sinusitis. Roentgenograms revealed a thickened pleura at the left base with infiltration in the left lower lobe, and tuberculosis of the upper left lobe.

Operation and Course.—A partial thoracoplasty was performed in four stages by resecting the third to the tenth ribs and costal cartilages. The lung was not adherent in the region where the pleura was exposed. The day following the fourth stage of the resection, symptoms of pneumonia developed, and an increased amount of sputum, at times blood stained, was raised. The sputum contained much elastic tissue. There was evidence also of consolidation of the right lung. The symptoms subsided after about three weeks, and the patient was dismissed in fair condition, but she still raised from 120 to 480 c.c. of sputum in twenty-four hours. She is to return later for the removal of the medial segments of the ribs resected. Her improvement has been progressive, as evidenced by an enormous appetite, progressive marked gain in weight and strength and diminution of cough and sputum. She has been able to work steadily since January, 1923.

Case 7.—*History.*—A frail anemic woman, aged 22 years, came to the clinic in December, 1922, on account of frequent attacks of chills with fever, cough and from 120 to 240 c.c. of sputum so foul as to cause nausea and vomiting. There was no known exposure to tuberculosis. At the age of 3 or 4, she had frequent, croupy colds, during which she coughed up bright frothy blood. At about the age of 12 years, she first coughed up a small amount of sputum. Hemorrhages continued, but were not so frequent. In 1919, following measles, the cough became more severe and sputum more foul, increasing to about 240 c.c. during twenty-four hours. Since that time, she had raised about this quantity of sputum during four coughing spells daily. She also had pain in the right side of the chest, and dyspnea on exertion. She weighed 91 pounds (41.3 kg.).

Examination.—There was tenderness to palpation, and dulness to percussion at the right base posteriorly, where friction rub and occasional râles were also heard. The left border of the heart was displaced 3 cm. inside the left nipple line. Roentgenograms revealed sacculated bronchiectasis involving the right lower lobe.

Operation and Course.—A graded thoracoplasty was performed in seven stages, the full length of the second to the eleventh ribs inclusive being resected. There were no postoperative complications. As a rule, the patient was out of bed by the third day after operation. Her weight dropped to 89 pounds (40 kg.); hemoglobin from 70 to 35 per cent.; and the sputum increased to about 300 c.c. in twenty-four hours. Following the completion of the plastic collapse, the sputum, on certain days, amounted to 30 c.c.; on other days, it was

nil. Improvement continued after the patient returned home. She has had almost no cough nor sputum; has gained 20 pounds (9 kg.); is doing all her own housework; has no disability or deformity, and looks perfectly well.

During the last three months, three other patients with typical bronchiectasis have been operated on similarly. In one case, the phrenic nerve has also been resected on the affected side. They have all recovered satisfactorily, without complications, but sufficient time has not elapsed to indicate what the final results will be.

Graded thoracoplasty has been performed also for abscess of the lung with complicating bronchiectasis in eight cases. Three of these patients died after operation, and the presence of multiple abscesses and typical bronchiectasis was proved in all. Two of them had bilateral abscesses. The cause of death in one was primarily a transverse myelitis of the cord, probably due to a centrifugal infection extending along the intercostal nerve. A fourth patient died after he returned home. Postmortem examination was not made. Two were operated on recently.

Remarkable improvement, approximating cure, was obtained in two cases. One patient was a school teacher who, for five years, had been a recluse on account of the stench from her breath and sputum. Except for two or three short remissions, during which she has coughed and raised a small amount of sputum, she has been practically free from symptoms since operation.

SUMMARY

The principles in the surgical treatment of bronchiectasis have been drainage, extirpation and collapse of the lung. In the earlier cases, when drainage was attempted, the mortality was very high, and improvement was obtained probably only in cases of localized saccular bronchiectasis, where indeed the procedure may be indicated. Pneumonectomy is, theoretically, the ideal operation, but it has been considered suitable only in a selected group of young patients, and among such selected patients (reported cases), it has yielded a 47.8 per cent. mortality, and a cure in less than 20 per cent. Collapse therapy includes, essentially, artifical pneumothorax and extrapleural thoracoplasty. Pneumothorax collapse is a relatively safe procedure, but has to be continued months or years, and even then has yielded only a small number of reported cures; and empyema is a complication in a high percentage of cases. A single-stage extrapleural thoracoplasty has yielded a high mortality, but many cures have been reported.

In a series of ten cases of diffuse unilateral bronchiectasis herein reported, extrapleural thoracoplasty was performed in from four to seven stages under nitrous oxid and oxygen anesthesia, followed by alcohol injection of the intercostal nerves to minimize pain and the

voluntary postoperative inhibition of coughing. Thus far there have been no deaths. Six patients have good general health. Three of these are practically free from symptoms; three raise from 30 to 60 c.c. of sputum in twenty-four hours, and one has symptoms and signs suggesting extension of infection to other portions of the lungs, but raises only about 60 c.c. of sputum in twenty-four hours. None has shown disability, or marked deformity. Three patients are still convalescent.

On the basis of comparative results, therefore, graded extrapleural thoracoplasty would seem to commend itself to consideration in the treatment of diffuse unilateral bronchiectasis. Its relative safety also makes it adaptable to most cases.

BRONCHIECTATIC PULMONARY ABSCESS SIMULATING APICAL TUBERCULOSIS

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In the course of years, a certain routine has been worked out in my division of the Lenox Hill Hospital, not only for quickly establishing the definite diagnosis in cases of pulmonary suppuration but also for determining the treatment that appears best suited to the individual case. All this, it seems to me, is of great importance to these patients now that the mist that has been hanging over this whole question is slowly beginning to rise.

While no doubt the majority of hospitals of standing proceed on similar lines in this particular branch of surgery, there still seems to be considerable difference of opinion regarding details, as shown by discussions of the subject in the course of the last months.

In an effort to reconcile these conflicting views, a detailed report of a case of bronchiectatic abscess in the uppermost pole of the superior lobe of the right lung, at first sight simulating apical tuberculosis, is herewith presented.

Before reporting the case itself in its various aspects, I wish to touch briefly on our mode of procedure in establishing the diagnosis.

When a patient with expectoration of purulent sputum has been admitted to the surgical division and the trouble has been grossly located, a full history is taken, covering in detail all possible etiologic factors, just as is done in other patients. This is followed by a most careful clinical analysis of the disease, and examination of the entire body: inspection of the chest, fingers and toes; percussion with auscultation, and laboratory analyses of blood, urine, sputum, chemical, microscopic and bacteriologic. Then one of the attending physicians is asked to see the case. Should the laboratory report absence of tubercle bacilli, when a suspicion of this type of lung suppuration exists, we do not rest the case, but proceed to prove or disprove the correctness of the statement by all the latest methods at our command. The Wassermann test, of course, is never omitted, although the fact that a negative Wassermann means very little, clinically, is not lost sight of. Nothing is less justifiable in any chapter of our science, it seems to me, than to dismiss the diagnosis of syphilis on the basis of a negative Wassermann test. And yet, how frequently is this mistake committed. After all, it is the history and clinical manifestations that must decide the question. On the other hand, a positive result of the test is naturally of

utmost importance, and will at once enable us to decide as to the treatment. We should remember that even far advanced specific pulmonary suppuration has yielded completely to antisyphilitic treatment.

The next step in the logical sequence of examinations is roentgenoscopy. Hardly in any other part of the body has Roentgen's discovery brought greater advance than in the diagnosing, localizing and classifying of diseases of the lung. This fact has been recognized the world over. Almost daily, new methods of refining the diagnosis of diseases of the chest are added. Today, not only are we able to read from the film the localization of the affection; its unilocular or multilocular existence; a cavity formation with fluid level, in front and side views, in the erect and horizontal posture; signs for etiologic or coexisting tuberculous affection, etc., but also by a close study of the density of the infiltration surrounding the focus, we are able to speculate on the postoperative prognosis. A thick inflammatory wall surrounding an abscess cavity of long standing points to a reduced chance of spontaneous closure of the cavity after free incision and drainage. This, of course, is of comparatively little importance in quite a number of cases of suppuration of the lung today, since we know that a less dangerous operation than lobectomy, that is, prolonged drainage and thorough aeration of the focus, is liable to bring about a complete and permanent cure of the existing disease in quite a number of cases, the lung lip-fistula working as a permanent chimney for the affection in the depth of the lung. Of course, should a patient tire of carrying the fistula, another operation, to be performed in one or more stages, will be required. The advisability and the extent of such a secondary operation will depend on the local conditions in the respective case.

In his examinations and conclusions with regard to the presence or absence of a cavity, the roentgenologist will, of course, not be guided by the surrounding infiltration and the fluid level alone. He knows that some of these cavities do not contain an appreciable amount of purulent fluid, but a number of pieces of coagulated fibrin with grumous material, as pointed out in a paper on this subject last year.[1] These soft masses of coagulated fibrin, with the neighboring lung-tissue in chronic putrid inflammation, are the continuous inciting cause of and are mostly responsible for the persistent fetid expectoration. But a cavity thus filled cannot present a typical fluid level.

Regarding the always greatly to be desired, but not always attainable definite roentgenographic localization of the focus within the thoracic

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1. Meyer, Willy: Observations on Lung Suppuration and Its Treatment. A Brief Review of Personal Experiences and Clinical Impressions Obtained Within the Last Twelve Years, Arch. Surg. **6**:361-425 (Jan.) 1923 (Part 2).

cavity with its large dimensions, it is comforting to know that many roentgenologists are hard at work today in an endeavor to solve this problem.[2]

As stated in my previous article,[1] the thoracic surgeon absolutely needs this roentgenographic assistance. Nothing is more perplexing and more liable to cause him worry than to be obliged, in a case of suppuration of the lung, to rely on the aspirating needle alone for the definite localization of the focus, before the knife is resorted to.

After the completion of the roentgenologist's work, that of the bronchoscopist follows, in logical sequence. As I have often stated the roentgenologist and bronchoscopist are the surgeon's closest friends. Of course, the bronchoscopist must be thoroughly trained, in order not to do harm to the patient, and to interpret properly the picture he sees. A faithful and intelligent assistant is of paramount importance to him. Team work is the key note of his success. He will find within the bronchi and their ramifications the foreign body or the foreign semisolid substance which so often is alone responsible for the tormenting, chronic affection of the lung; he will tell us definitely, after proper evacuation of the bronchial tree by suction, which lobe or lobes are discharging pus; then, comparing his findings with those of the roentgenologist, he will remove a piece of suspicious tissue from the bronchial wall and therewith enable the pathologist to establish the diagnosis "broken down malignant tumor." He will see and define the characteristics of a stricture at the entrance to the stem bronchus, and will tell the surgeon whether there is hope for improvement by regular intrabronchial treatment.

A joint consultation among all who have examined the patient is most desirable at this time. The decision reached will make it possible to outline the course of treatment and determine whether the patient has to remain at the hospital or may become ambulatory for a time. Only those patients who are evidently affected with typical bronchiectasis—that multiple, honeycomb-like suppurating condition of the lung, usually of one or both lower lobes and, I believe, dependent on a congenital malformation—present, according to our present view, surgical cases from the start. Bronchoscopic treatment will not improve them: they need operation; if they desire to be completely cured, extirpation of the affected portion of the lung; or, if disinclined to take the risk of such radical work in view of the still high mortality of lobectomy, one of the more conservative operative procedures, proposed for the surgical treatment of this trouble, or a combination of some of them. The other patients fare best, it seems to me, if they are turned over to the bron-

2. Trendelenburg Wilhelm: Stereoscopic Measurement of Space in X-Ray Pictures, Monograph, Tübingen, Germany, Berlin, Julius Springer, 1917.

choscopist first; for it has been seen that acute as well as subacute and chronic cases of this type can be permanently cured by regular intrabronchial treatment. We have found it feasible to have these patients go to the bronchoscopic clinic direct, or to have them admitted one day before treatment is to be instituted and keep them at the hospital for from one half to one day afterward.

In further consideration of the cause of suppuration in the given case, the surgeon will bear in mind the possible presence of actinomycosis, or the breaking-down of a gumma or of a malignant tumor, as just mentioned.

The surgeon will also not forget the possibility of spontaneous cure of a pulmonary abscess, when he makes his decision regarding operative advance.

Proceeding in this way, the combined medical, surgical and specialistic forces can conscientiously claim that they are doing the very best that can be done for the patient.

REPORT OF CASE

History and Examination.—M. K., a gardener, aged 38, in June, 1920, noticed a peculiar odor of his breath without any apparent cause. On the following day, his temperature rose above 104 F., and he entered a local hospital. Two days later, he began to expectorate foul-smelling sputum, more or less mixed with blood. He had an occasional pain in the right side of the chest. After six weeks, with little improvement, he went home, where he was confined to his bed for six months. He then returned to his work although by no means well, continuously raising sputum with a fetid odor, and often mixed with blood. From January, 1921, to the spring of 1922, he passed through two distinct attacks of exacerbation of the trouble, with the same symptoms as experienced at first. He was kept in bed for many months each time. For a while, he was in a New York hospital, where medical treatment was given. In June, 1922, he was referred to me by his family physician, Dr. G. M. Gilchrist of Groton, N. Y., greatly reduced in general health, but still weighing 152 pounds (68.9 kg.) He had been a very powerful man before the trouble developed. The history revealed no aspiration of a foreign body. The patient had always been well. He had never had an attack of pneumonia, but had had influenza three years previously. He was perfectly healthy in the years after the attack. There was no history of tuberculosis in the family; and he never had a syphilitic infection. The fact that the trouble had existed for two years, together with the patient's good general condition and the laboratory findings, precluded the presence of a cancer or a hydatid. Nor could actinomycosis be considered, as the organism was not found. The temperature was frequently above 102 F. There was a pronounced tympanitic percussion sound anteriorly and directly below and above the right clavicle, with dulness further down, to the fourth rib and posteriorly at the apex; loud amphoric or bronchial breathing with gurgling râles over this area, and a whispering voice, all of which pointed to a cavity formation in the upper lobe of the right lung with fibrosis of this lobe, not of tuberculous character. (Report by Dr. O. Schwerdtfeger, who had been called in consulta-

tion, June 16, 1922.) Repeated examination showed that the sputum had three layers and contained no elastic fibers or tubercle bacilli. The amount for twenty-four hours was between 300 and 600 c.c. The Wassermann reaction was negative.

The roentgen ray showed a fluid level in several small cavities and shadows in the upper right lobe toward the sternum, but no characteristic signs of tuberculosis (Fig. 1).

Bronchoscopy (Dr. R. Jordan), June 15: Only the right upper lobe was involved. The upper lobe branch orifice was surrounded by edematous, granulating tissue. The orifice was not very much constricted. There was a copious discharge with pus and blood from the right upper lobe. All the other bronchi were free.

The symptoms found tallied best clinically with the assumption of the presence of a broken-down tuberculous or syphilitic focus, with cavity formation, but the laboratory and other findings did not support such a diagnosis. Thus, the etiology of the trouble remained obscure. The supposition of a circumscribed pulmonary embolus with a low-grade infection—the patient had had signs of a chronic cholecystitis—or of an infected localized thrombosis of nonvirulent type in the branches of the pulmonary vein at the apex of the right upper lobe, producing a local bronchiectatic abscess of the lung due to gangrene, seemed the most plausible.[3]

At a consultation of those who had examined the patient, temporary conservative treatment at the hands of the bronchoscopist, with regular intravenous neo-arsphenamin injection, was decided on.

From June to December, 1922, the patient received twenty-three intrabronchial treatments, suction, injection of a silver preparation at the hands of Drs. R. Jordan and J. D. Kernan, Jr., with the result that he gained weight and was free from fever, and the offensive odor of the sputum, which was greatly reduced in quantity, was now absent. A roentgenogram taken several months after admission also showed unmistakable reduction in size of the pulmonary focus and clearing up of the formerly irritated appearance of the other parts of the right upper lobe. The infiltration of the right upper lobe had become more concentrated. There was no large cavity with a fluid level; but rather a number of small ones in the first intercostal space. (Report of Dr. William H. Stewart.) But cough and some expectoration continued. After eight weeks of further treatment the bronchoscopist still found granulation tissue about the mouth of the upper lobe bronchus, though with less secretion. Clinical examination, too, proved the abscess cavity to be more localized and more marked toward the sternum. There was still the tympanitic sound above and below the

3. The occupation of the patient—he is a gardener—also suggests manuring as a possible factor in the etiology of his case. Human excreta are commonly recognized as a source of infestation with intestinal parasites. The massive entrance of the larvae of nematodes (as experimentally seen by Yoshida producing an engorgement of alveoli with red blood corpuscles) when on their typical migration, might also be thought of as a possible cause of lung suppuration in etiologically obscure cases. In such cases, repeated examination of the stools for ova might clear up the question. Sud is another frequently used manure in gardening. While the pulmonary lobes generally might be able to throw off the accidentally inhaled powder, the poorly ventilated apex might be unable to do so. The strong chemical irritant, permanently lodged at the apex, might bring on inflammation and eventually suppuration.

Fig. 1.—Appearance of chest on day of admission. The right upper lobe with apex is densely infiltrated. The small cavities are not discernible.

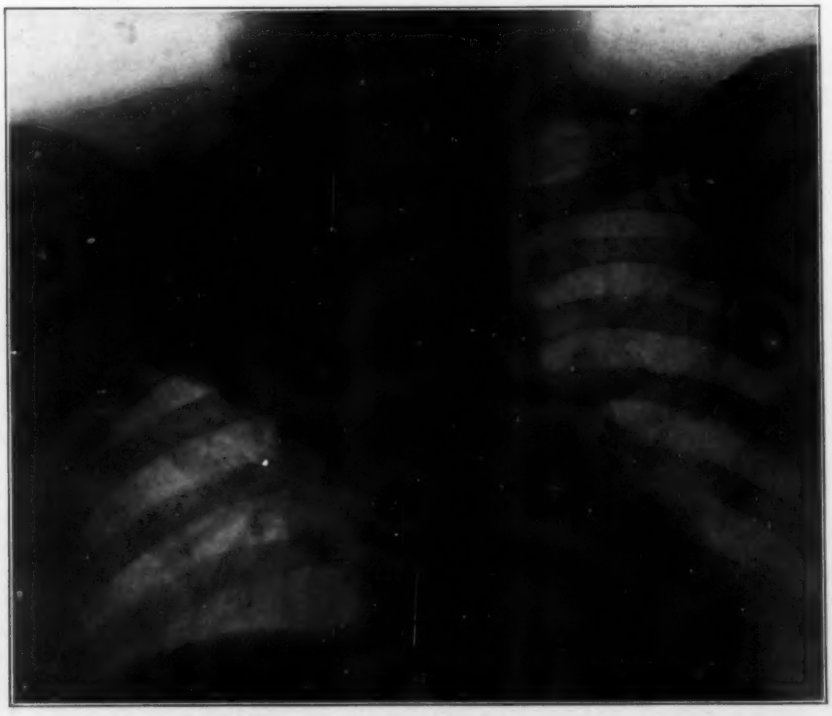

Fig. 2.—Condition after five months of weekly intrabronchial treatment. The original diffuse affection of the right upper lobe has disappeared and the inflammatory focus is more clearly defined.

right clavicle, with dulness in front, down to the second rib, and loud bronchial breathing over the same area, pointing to cavity formation with pronounced fibrotic change of lung tissue (Dr. Schwerdtfeger). The roentgen-ray findings at that time are shown in Figure 2.

At another conference, early in December, it was decided to institute surgical treatment. It was the intention to resect the first and second ribs, make an incision at the apex of the lung with drainage, and establish a lung lip-fistula.

Operation (Dec. 15, 1922).—A hypodermic injection of one-quarter grain of morphin with 1/150 grain of atropin was given one hour before operation. The upper part of the body was raised on cushions, and the right arm, hyperextended and abducted, was held by a nurse. Local and regional anesthesia, 0.5 per cent. procain-epinephrin was induced; also the line of the incision below the clavicle was anesthetized. The latter runs slightly convex downward from the border of the deltoid muscle to the sternoclavicular articulation. Such downward convexity of the skin incision is particularly advisable in the upper portion of the thorax, because the upper skin flap then falls down and facilitates the lining of the superior circumference of the lung fistula with scar tissue. Further division of the superficial fascia and pectoralis major muscle bundles, incision of the deep fascia, and stretching of the wound with the fingers, thus exposing the border of the pectoralis minor muscle and, clearly, the subclavian vein in the outer angle of the wound, were carried out; also incision of the pectoral muscle bundles upward and downward, perpendicularly to the direction of their fibers, for a short distance, thus laying open well the first intercostal space.

A piece of the second rib was first excised, as the first is not easily accessible for primary resection. Superficial incision of the intercostal tissues, which exposed the lower border of the first rib, and incision of the periosteum and perichondrium of the latter, which were pushed aside, was next carried out. The first rib, which was at least 1 inch (2.5 cm.) in width, was denuded with a curved periosteal elevator, and the bone was divided with long and properly curved rongeur forceps. By holding the subclavian vein well upward with a finger of the left hand and "biting" away bone on either side of the first cut, a gap of almost an inch was made in the first rib. There followed aspiration of the lung in the first interspace corresponding to a line meeting the middle of the clavicle, making the tip of the needle first point inward. The result was negative, as a resistant tissue was encountered by the tip of the needle.

Exploration was not pressed, as some arterial bleeding, stopped by compression, followed this step of the operation. Now the aspirator was turned perpendicularly downward and slightly upward toward the apex, i. e., in a line parallel with the longitudinal axis of the body. It clearly passed through infiltrated, liver-like tissue, and suddenly entered a cavity, from which some flaky pus was withdrawn. The actual cautery then divided the lung, first in a horizontal and afterward also in a perpendicular line, making an inverted T-shaped incision. A larger cavity was not entered. The finger introduced, after some motion of the tip inside, slipped into a smooth mucosa-lined cavity within the very apex of the lung, and also entered a number of adjoining smaller cavities downward, which were gently and gradually united in a blunt fashion, without hemorrhage. On closing his mouth and compressing his nostrils, the patient was now able to blow air through the incision of the lung, a fact

which insured the division of a larger branch of the upper lobe bronchus. Drainage of the irregular pulmonary cavity was carried out by means of two split drainage tubes and iodoform gauze. The soft tissues of the chest wall were loosely packed with aseptic gauze tampons, and the dressing kept in place by broad adhesive plaster strips.

Outcome.—The patient stood the operation well, and the pulse was excellent at its completion. A great deal of bloody expectoration had occurred during the latter part of the operative work. The patient was made to sit up in bed, and was given morphin in larger doses repeatedly. The bacteriologic examination of the aspirated pus as well as the culture of some tissue of the lung

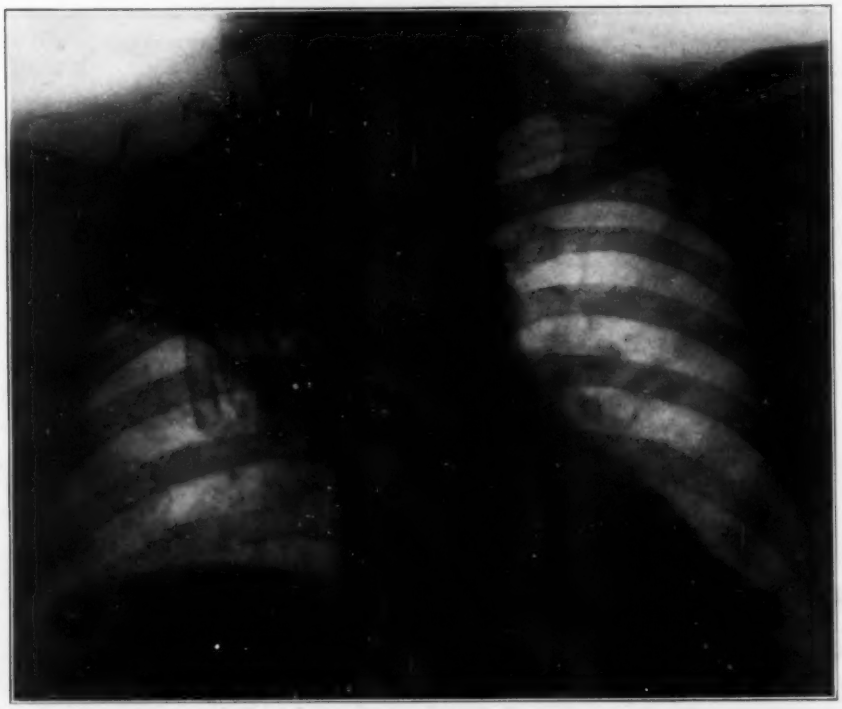

Fig. 3.—Permanent drainage tube in place. In the roentgenogram, which is taken from the back, the tube appears to run downward, but this is not the case. When introduced in front, its direction is backward and upward. On stereoscopic examination, the infiltration of the lung is seen to be greatly reduced, particularly at the apex.

which had been extirpated with the cautery in dividing the lung revealed *Staphylococcus pyogenes-albus* in pure culture. At the end of the first week, the deep dressing was changed, the gauze tampons were removed and an all-round drainage tube was introduced. Two weeks later, the lip fistula began to form, and expectoration was found to be greatly reduced. The fetid odor of the sputum, formerly occasionally present, had not returned.

Six weeks later, the stereoroentgenogram demonstrated a marked clearing up of the formerly densely infiltrated tissue of the lobe and apex (Fig. 3).

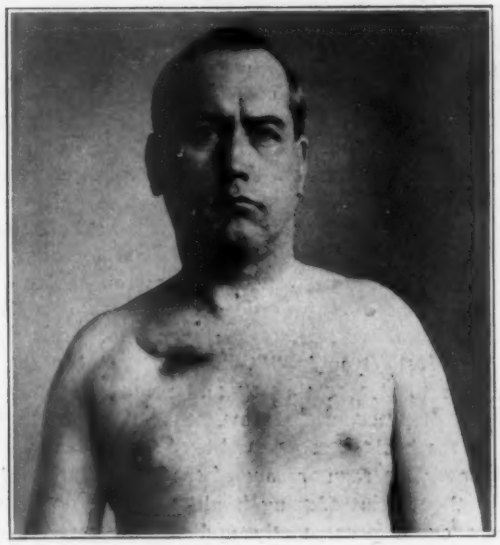

Fig. 4.—Lung lip-fistula, well established in its upper circumference. The lower half of the center of the otherwise cicatrized wound is still granulating. It is treated daily with the superheated air-douche. The tube is completely removed and the permeability of the lung fistula is daily tested with a flexible bougie.

Fig. 5.—Permanent drain again in place, to be worn until the circular scar formation is complete and extends into the canal for some distance, thus insuring the desired lung lip-fistula for prolonged drainage and ventilation of the deep-seated inflammatory focus.

In the further course of the after-treatment, the granulations surrounding the drainage tube that leads down to the bronchial opening showed marked resistance to cicatrization in spite of curetting combined with actual cauterization and sucessive trying out of every conceivable method known regarding dressing of a granulating wound. The systematic daily use of the superheated air-douche for the granulations seemed to best keep them in check, while the drainage tube was at times completely removed (Fig. 4) and the canal daily tested with an olive-pointed, well anointed flexible bougie, which slipped in for many inches and was distinctly felt by the patient as being well within the right bronchus. Evidently, the permanent presence of the tube was the cause of the difficulty in obtaining cicatrization, which was necessary in order to finish the required *circular* scar-lining of the chimney that led down to the slowly extinguishing focal trouble within the tissue of the lung. Nature evidently wanted here to close the canal and refused to lend a helping hand in the surgeon's plan of procedure. I have seen this twice before in similarly treated cases, when the husband or the wife of the patient who, after demonstration, had taken over the regular care of the wound, allowed the permanent drain to slip out without reintroducing it although the lip fistula had formed. Both patients were cured permanently and are in perfect condition today. However, on account of the location of the inflammatory focus in this particular case, within the very apex of the lung, I am insisting on the patient's continuing to wear the tube, because we know that the apex is the poorest area as regards thorough ventilation (Fig. 5). This has also been shown in this case by the observation that, in spite of a wide bronchial communication, breathing through the fistula with mouth and nostrils closed proved to be insufficient for the exchange of gases needed by the patient, since slight cyanosis set in after a while. If such a bronchial fistula communicates with the bronchial tree further down, some distance below the level of the bifurcation of the trachea, patients usually are well able to draw in and to discharge all the required air through the canal in this type of retrograde respiration.[4]

Comment.—I feel that the muscle bellies of the pectoralis major and minor are principally responsible for the mechanical difficulty encountered in gaining thorough circular cicatrization in this case. In another similar instance, in a strong, well-developed patient, I would excise a big chunk of both pectoral muscles clear down to the ribs, or I would divide the muscles perpendicularly to their fibers well up to the clavicle and also downward, in order to insure thorough retraction of the elastic muscular tissue. The lip-fistula will form more promptly, I believe, if the skin touches the intercostal space directly. I have proposed this procedure to the patient as an alternative should he become weary of wearing the tube and of the necessity of regular dressings.

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4. December 1, I was informed by the patient's physician, that about November 20, he had complained of a pain in the upper part of the chest and subscapular region, particularly on moving his right arm, with rise of temperature to 101 F. Three days later a large amount of muddy, foul-smelling pus and blood was discharged through and around the tube, after which the pain ceased at once and the temperature subsided. If anything proves the value of long-continued drainage and an attempt to form a lung lip-fistula, it is an experience like this, which has been observed also in other patients. Prolonged direct drainage of the pulmonary focus to the surface of the body represents a safety valve in the true sense of the word.

Meanwhile, he has gone home in fine general condition, with his weight greatly increased, and cough and sputum almost gone. The plan is to let the patient wear the drainage tube for another five to six months at least and then remove it tentatively, incidentally concentrating all efforts on the thorough establishment of the pulmonary lip fistula. According to the last report, received from the patient five days ago, he is continuing to improve steadily. He is up and about, feeling fine and intends to resume his work as gardener soon.

EXPERIMENTAL CLOSURE OF LARGE BRONCHI

A STUDY OF THE FACTORS CONCERNED IN FAILURE OF THE BRONCHI TO HEAL *

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From the experience had in France with lung wounds; from the experience gained afterward in civil practice with empyema associated with bronchial fistulas, and from a review of the literature, it seemed that one of the great obstacles which now remained in the path of chest surgery was the failure of the large bronchi to close. We set about endeavoring to develop a technic for closing bronchi. We were greatly cheered by the article of Heuer [1] and his associates, who claimed that the closure of a large bronchus was a simple matter. The purse string method, the invagination method and even the simple mass ligature gave good results in their hands. It must be admitted that, while reading their article, it was rather disconcerting to recall our own numerous failures, and those reported from the clinics of Lilienthal, Sauerbruch and many others.

After a protracted study of the subject and after numerous experiments, it must be admitted that we have not been able to close large bronchi with any certainty of success by any of the methods reported. We have arrived at conclusions diametrically opposed to those of Heuer. According to our experiments, an isolated large bronchus will not heal. Smaller bronchi can be sealed, but the tissue which closes them is not derived from the bronchi themselves but from peribronchial structures. In short, following a pneumectomy, our dogs almost invariably (there were two exceptions) died. Following simple lobectomy, the dogs almost always lived; but on inspection of the tissues removed later at necropsy, the healing of the bronchus was found to have resulted from an overgrowth of adjacent structures.

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* The histologic work was carried out under the supervision of Dr. O. T. Schultz, Director of the Nelson Morris Institute.

* From the Nelson Morris Memorial Institute for Medical Research of the Michael Reese Hospital and the Surgical Department of the Northwestern University Medical School.

1. Heuer, G. J., and Dunn, G. R.: Experimental Pneumectomy, Bull. Johns Hopkins Hosp. **31**:31 (Feb.) 1920.

EXPERIMENTAL DATA

The experiments were all conducted on dogs. In every case, intratracheal insufflation anesthesia was used. The apparatus was extremely simple. A laboratory bottle with the usual double glass tubes held the ether and was connected by one of the glass tubes through a mercury manometer to the tracheal catheter. The air pressure was derived from a foot bellows connected by means of a rubber hose to the other glass tube. The dogs were carefully prepared for operation, and during operation all rules of asepsis were rigidly adhered to.

The experiments were divided into three groups.

In the first group, a simple lobectomy was performed, one, two, or three lobes of the lung being removed. After varying intervals, the dogs were killed with ether and the bronchial stump was removed and sectioned. In the second group, a total pneumectomy was performed, the entire right lung being removed. The bronchial stump was closed by various methods. In a third group, which consisted of but three dogs, a ligature was placed about the bronchus and the lung left in situ.

Group 1.—Technic: In Group 1, one or more lobes of the lung were removed with the following technic:

An intercostal incision was made from the sternum to the midaxillary line in the fifth interspace. By the use of a heavy self-retaining retractor, a large opening into the chest wall could be made, one adequate for careful inspection of the chest cavity, and ample for all manipulations. The middle lobe of the right lung or the two middle lobes were pulled out of the wound. The blood vessels were ligated with catgut ligatures and cut. The bronchus was clamped, cut and ligated with a simple ligature of No. 2 catgut. This entire procedure was accomplished without difficulty. The lobes of the lung were easily delivered; the blood supply lay ventrally where clamping could be done easily, and the bronchus dorsally where it was readily accessible. The chest wall was closed in layers. Two catgut sutures were passed about the two separated ribs; the muscles were sutured, and following this the skin. The entire operation did not require twenty minutes; there was very little shock, and the dogs recovered and regained their former well being in a very short time. The wounds healed well. No postoperative dressings of any description were used.

The intratracheal catheter was inserted before operation was started, after the dog had been anesthetized, but the insufflation was used simply during the time the chest cavity was open.

Results of operations: The dog usually lived. It seemed to suffer no respiratory embarrassment beyond what might be expected after administration of any general anesthetic. Within a week, it was let out of its individual cage and within a day or two was running about the dog pen, jumping, playing and fighting with the other dogs as if nothing had happened.

TABLE 1.—*Experimental Data* *

Dog	Operation	Date	Treatment of Stump	Died		Lived, Days	Necropsy. Date	Necropsy Findings	Findings in Section
				Date	Days				
1	Lobectomy right upper	11/30/20	Mass ligature	12/ 5/20	6	..	12/ 5/20	Emphysema subcutaneous; no pus; ligature had opened slightly	
2	Lobectomy	12/ 5/20	.....	12/ 5/20	..	..	12/ 5/20	Died during operation from difficulty in giving ether	
3	Lobectomy right lower	12/ 5/20	Mass ligature	.....	..	..	12/ 5/20	Killed at end of operation by accidental cutting of sinus; both lungs showed emphysematous blebs; highest intratracheal pressure 9 mm. Hg	
5	Lobectomy right upper	1/11/21	Mass ligature	1/12/21	1	..	1/12/21	Nothing pathologic; shock	
6	Lobectomy right middle	1/26/21	Mass transfixion	1/31/21	5	..	.....	No necropsy	
11	Lobectomy right middle and lower	10/ 3/21	Mass ligature	.....	..	55	12/27/21	Chest clear; stump healed....	Stump healed by thin membrane
25	Lobectomy right lower	2/16/22	Mass ligature	.....	..	15	3/ 3/22	Chest clear; stump healed....	Bronchus well healed
26	Lobectomy right lower	2/16/22	Mass ligature	.....	..	32	3/20/22	Chest clear; upper two lobes atelectatic; involved in adhesions	Bronchus well healed
24	Lobectomy right lower	2/16/22	Mass ligature	.....	..	90	5/19/22	Chest clear.....	Large cyst formation
29	Lobectomy right middle	3/ 1/22	Mass ligature	3/ 8/22	7	..	3/ 8/22	Emphysema mediastinal and subcutaneous; bronchus lower lobe opened	
42	Lobectomy right upper	12/12/22	Mass ligature	.....	..	14	2/26/22	Chest clear.....	Bronchus well healed

* The first cases (1, 2, 3, 5, 6) were performed under difficulties, with insufficient assistants, etc., and the results have little significance.

TABLE 2.—*Experimental Data*

Dog	Operation	Date	Treatment of Stump	Died		Lived, Days	Necropsy, Date	Necropsy Findings	Findings in Section
				Date	Days				
4	Pneumectomy	12/16/20	Mass ligature	12/19/20	3	..	12/19/20	Fluid in chest; bronchial ligature still held (dog sick with diarrhea before operation)	
7	Pneumectomy	1/27/21	Stump inverted with double cross silk	.....	..	250	.....	Dog ran away	
8	Pneumectomy	2/ 8/22	Stump inverted with chromic	12/14/22	6	..	12/14/22	Diffuse pleurisy (right side)	
9	Pneumectomy	2/10/22	Plastic operation on stump with silk	2/15/22	5	..	2/16/22	Purulent exudate in chest; ligature still in bronchus	
10	Pneumectomy	2/17/21	Plastic operation on stump; stump inverted with silk	2/22/21	5	..	2/22/21	Exudate in chest	
12	Pneumectomy	3/ 5/21	Stump inverted with silk	3/10/21	5	.	3/10/21	Opening of bronchial stump; no infection; subcutaneous emphysema; stump sloughed	
13	Pneumectomy	3/12/21	Stump inverted with silk	3/16/21	4	..	3/16/21	Opening of bronchial stump; no infection; subcutaneous emphysema; stump sloughed	
14	Pneumectomy	3/12/21	Stump inverted with silk	3/16/21	4	..	3/16/21	Opening of bronchial stump; no infection; subcutaneous emphysema; stump sloughed	
15	Pneumectomy	11/29/21	Ligature of one secondary; two tertiary bronchi	12/ 4/21	5	..	12/ 4/21	Bronchus reopened	
16	Pneumectomy	12/20/21	Mass ligature	12/20/21	1	..	12/20/21	Negative except for greatly distended intestine (catheter had slipped in esophagus at end of operation)	

TABLE 2.—*Experimental Data—(Continued)*

Dog	Operation	Date	Treatment of Stump	Died		Lived, Days	Necropsy, Date	Necropsy Findings	Findings in Section
				Date	Days				
18	Pneumectomy	12/20/21	Mass ligature	12/20/21	1	..	12/20/21	Injury to vena cava	
17	Pneumectomy, entire right lung	12/13/22	Secondary bronchi ligated	.....	..	36	1/17/22	One adhesion to stump from chest wound; stump clear, not buried; bronchi rounded but thinly covered	Thin walls and cyst
20	Pneumectomy, entire right lung	1/ 3/22	Crushed two main bronchi and ligated with silk	1/ 8/22	5	..	1/ 9/22	Subcutaneous emphysema; main bronchi had cut through	Hemorrhagic infection of occluded bronchus
22	Pneumectomy, entire right lung	1/17/22	Bronchus crushed and ligated with fascia lata	1/23/22	6	..	1/23/22	Subcutaneous emphysema; entire portion distal to fascia had sloughed; no infection	
23	Pneumectomy, entire right lung	1/24/22	Stump inverted with silk	1/29/22	5	..	1/20/22	Subcutaneous emphysema; stump sloughed at site of inversion; no infection	
28	Pneumectomy, entire right lung	2/21/22	Secondary bronchi crushed and ligated	2/28/22	7	..	2/28/22	Bronchi sloughed; pus in chest	
37	Pneumectomy, entire right lung	9/19/22	Two main bronchi crushed and ligated	9/23/22	4	..	9/24/22	Hemorrhage from vena cava which had been repaired; stump still held by sutures	
38	Pneumectomy, entire right lung	9/20/22	Secondary bronchi crushed and ligated	9/25/22	5	..	9/25/22	Stump sloughed; no infection; subcutaneous emphysema	
35	Pneumectomy, entire right lung	9/ 5/22	Vastus externus muscle placed in right bronchus; bronchus crushed and ligated	9/10/22	5	..	9/10/22	Necrotic stump sloughed; pneumothorax	

36	Pneumectomy, entire right lung	10/12/22	Implantation of muscle held in place with silk	10/16/22	4	..	10/17/22	Slough of stump	
33	Pneumectomy, entire right lung	4/19/22	Bronchus invaginated by mattress sutures	4/22/22	2	..	4/23/22	Subcutaneous emphysema; stump buried in mediastinum	Acute suppurative inflammation of bronchus
39	Pneumectomy, entire right lung	11/ 9/22	Bronchus curetted; mass ligature	11/13/22	4	..	11/13/22	External chest clear; bronchus opened	Bronchial tissue not reacting
40	Pneumectomy, entire right lung	11/12/22	Bronchus cauterized with silver nitrate; mass ligature; dog in poor condition	11/26/22	4	..	1/27/22	No infection; some fluid in chest; stump sloughed	Bronchial tissue not reacting
41	Pneumectomy, entire right lung	11/29/22	Curetted; mass ligature	12/ 4/22	5	..	12/ 5/22	Bronchus patent; slough of stump	
19	Pneumectomy, entire right lung	12/27/21	Only secondary and tertiary bronchi ligated	1/ 6/21	6	..	1/ 7/21	Clear fluid in chest; lower branch of lower primary bronchus sloughed	
21	Pneumectomy, entire right lung	1/10/21	Tertiary bronchi ligated	1/13/21	3	..	1/13/21	Escape of air from upper bronchus	
24	Pneumectomy, left lung	2/14/21	Crushed secondary bronchi	2/20/21	6	..	2/20/21	Emphysema; 100 c.c. of pus; bronchus in mediastinum	

TABLE 3.—*Experimental Data*

Dog	Operation	Date	Treatment of Stump	Died		Lived, Days	Necropsy, Date	Necropsy Findings	Findings in Section
				Date	Days				
31	Occlusion of bronchus, left lung in place	3/21/22	.....	.....	..	20	4/13/22	Killed by intravenous injection of formaldehyd, 2 per cent.; upper lobe collapsed, lower expanded; right lower bronchus only partially occluded, upper two bronchi entirely occluded	Ligature cut through bronchus
32	Occlusion of bronchus with lung in place; heavy silk ligature	4/10/22	. ...	4/13/22	3	..	4/14/22	Pleural cavity filled with hemopurulent fluid (250 c.c.); a few fibrinous adhesions; bronchus occluded by a blood clot but silk ligature had cut through and lay in lumen	Hemorrhagic condition of bronchus
34	Occlusion of bronchus without removing lung; heavy silk ligature	6/ 6/22	.....	6/11/22	5	..	6/11/22	Ligature cut through into lumen	Ligature cut through into lumen

Necropsy findings: If necropsy was performed two weeks after the operation, the stump of the bronchus was visible as a small dome-shaped pouch protruding from the primary bronchus. The tip of this dome was composed of scar tissue. Proliferation of the peribronchial connective tissue was marked and had extended over the cut surface. The visceral pleura, that is, one of the adjacent lobes, was glued over the stump by adhesions. When necropsy was performed, a month later, the stump of the bronchus was barely recognizable. It consisted of little more than a dimple in the primary bronchus.

The chest cavity itself was usually clear. Occasionally, a thin string-like pleural adhesion was encountered. In one instance, this adhesion led down to the bronchial stump; otherwise, it led to one of the remaining lobes. Fluid was not found in the chest.

Microscopic examination in sections cut from the healed bronchial stumps revealed that the occluded end of the bronchial stump was blunt rather than conical. The walls of the bronchus tended to preserve the lumen. The epithelium quickly bridged the cut and appeared to be normal, high cylindrical, ciliated epithelium. It stained with normal intensity. The rest of the tissues in the bronchial wall did not show this regenerative power. The cartilage took a poor stain, the nuclei were few. The cartilage which was crushed during the ligation could be seen lying in the bronchial wall in irregular positions. Even in an animal allowed to live for ninety days after operation (Experiment 24), at necropsy this irregular position was maintained and there had been no attempt of the cartilage to conform to its normal position in the bronchial wall. In this case, the cartilage stained very poorly, contained very few, small compact darkly staining nuclei and showed no signs of regenerative activity. In other sections, the cartilage took on a bluish stain as if absorbing calcium, also a sign of degeneration. In Experiment 26, in which the dog was allowed to live for thirty-two days after operation, at necropsy one area in the section seemed to show the cartilage being replaced by fibrous tissue. The muscle of the bronchial stump seemed normal but apparently had not hypertrophied or in any other way aided in the closure of the stump. The fibrous tissue had reacted, and was increased. In no section, however, was the wall at the point of occlusion of the bronchus much thicker than normal. The increase in fibrous tissue was in the periphery of the wall of the bronchus; that is, the fibrous tissue seemed to have formed an envelop on the outside and had not to any appreciable extent forced its way between the cartilage and the mucosa.

In the majority of our sections, the remaining lung tissue was plastered over the cut end of the bronchus, and it was apparently this reaction which had saved the bronchus from reopening. The fibrous

tissue which had closed the bronchus seemed to have sprung from the visceral pleura and firmly held this pleural cap over the cut end. The lung just over the bronchial stump was usually atelectatic.

Another finding in our sections of occluded bronchial stumps was the presence of cysts. These cysts appeared in the blunt occluded

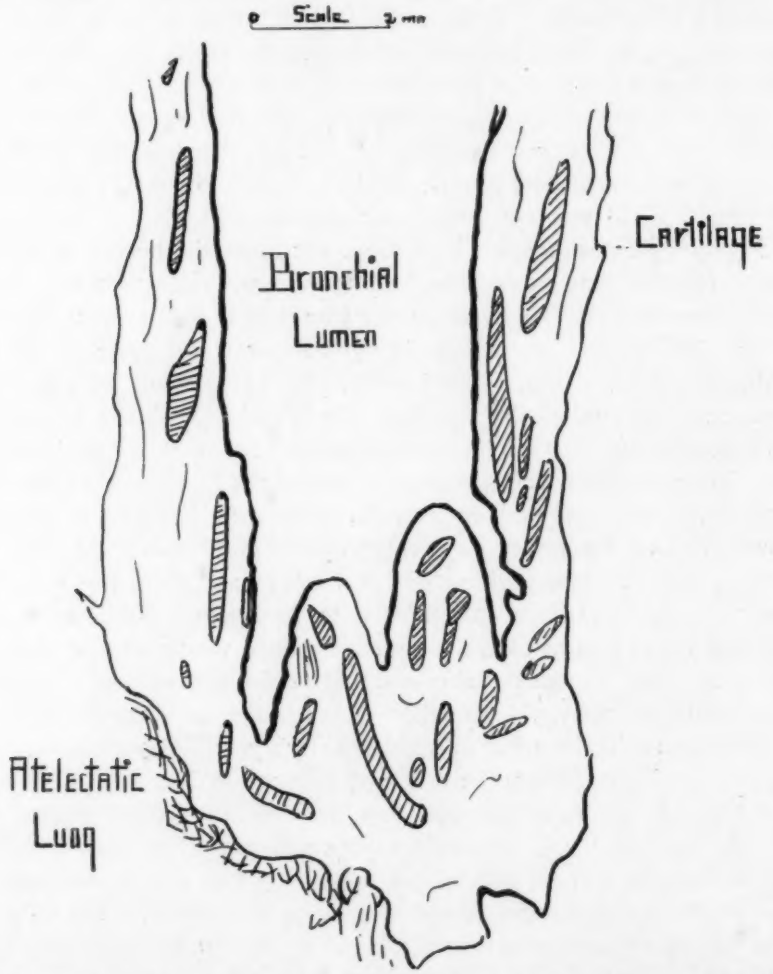

Fig. 1 (Dog 25).—Camera lucida diagram: Section fifteen days after lobectomy. The lumen was partly invaginated, the mucosa apparently entirely regenerated. The cartilage was crumpled and poorly staining, and a few nuclei were present. The atelectatic lung was plastered over the end of the bronchial stump. The bronchial wall itself was not thickened. There was occlusion, apparently from the tissue of the remaining lobes.

end, distal to the closure of the lumen. They were lined with epithelium, which at times was high columnar and at other times low

columnar. The high columnar cells resembled closely the cells of the normal bronchial epithelium, and their presence might indicate that the amount of intracystic tension was low. These cysts, we believe, were the result of the infolding of portions of the lumen by the ligature, and were not cysts in the sense that they had developed at that site. The position of the crushed cartilage about them would bear out this point. The importance of these cysts rested in the fact that their presence reduced the strength of the occlusion of the bronchus, and

Fig. 2 (Dog 25).—Photomicrograph of occluded end of bronchus shown in Figure 1. The epithelium had entirely bridged over the gap. The cartilage was very crumpled in most places, and stained very lightly.

what on gross inspection seemed to be a fairly adequate thick plug at the end of the bronchus contained in reality a much smaller amount of protective tissue than was expected.

Experiment 11 revealed an interesting condition which, it seemed to us, emphasized the inertness of the bronchial wall as far as regeneration is concerned. The entire lower half of the right lung was removed, leaving two small lobes. The bronchus was ligated with a single crush-

ing ligature. The dog survived. On necropsy, it was discovered that the bronchus was closed by a very thin membrane of connective tissue, which stretched across the bronchus much as a thin piece of rubber might be stretched over the end of metal tube. Any slight increase in pressure would undoubtedly have torn open the bronchus.

Group 2.—Technic: In Group 2, an entire lung was removed, usually the right. The size of the primary bronchus in the dog is such that the various methods of closure which have been described in the literature could readily be tried. Furthermore, its size is commensurate with the secondary bronchus in man. The technic of operation was the same as that adopted for lobectomy. Here again, we were surprised to find how easily the operation could be performed. The blood supply

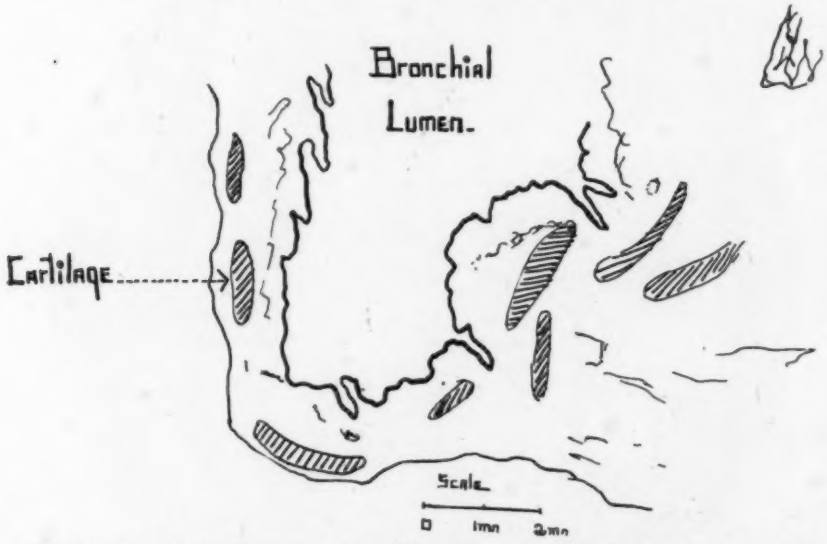

Fig. 3 (Dog 26).—Camera lucida diagram: Section, thirty-two days after lobectomy, showing a healed bronchial stump. This stump was more conical than is usual. The end was occluded by a wall not much thicker than the normal bronchial wall. The cartilage lying in the occluding tissue stained very poorly, and there were but few nuclei. This cartilage was evidently degenerating, and its position was probably due to mechanical pressure at operation and not to a designable growth. The atelectatic lung was firmly adherent to the end of the stump.

lay anteriorly, and ligation was easily done by means of an aneurysm needle. The bronchi were posterior and were readily seen by simply pulling the lung forward (ventrally). The stump was treated in many ways.

Results of operation: The dogs recovered quickly from the operation, and up to the fourth or fifth day seemed to be convalescing. Then, suddenly, death would occur. In several instances, the dog was seen

standing up, wagging his tail, apparently in excellent condition, and ten minutes later was found dead. At this time, it was often noticed that the animal had suddenly swelled, and on palpation subcutaneous emphysema was present.

Necropsy findings: The wounds were healing, there was no infection and subcutaneous emphysema was present, air evidently having

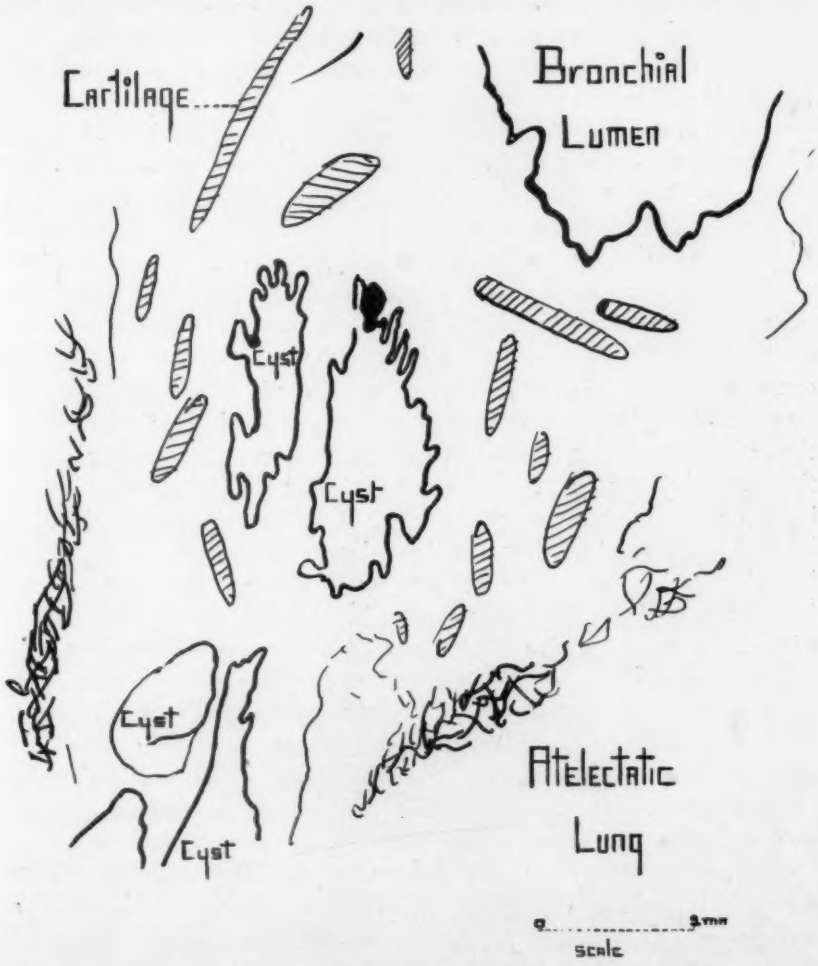

Fig. 4 (Dog 24).—Camera lucida diagram: Section, ninety days after lobectomy, showing cyst formation at the end of the occluded bronchus. The thin layer of tissue which separates the bronchial lumen from the cyst may be seen. The presence of cysts would naturally greatly weaken the occluded stump.

entered the subcutaneous tissue from within (that is, from the chest cavity) and not through the skin wound. The chest cavity contained a small amount of clear or slightly turbid fluid. In no case did there

seem to be an accumulation of pleural exudate sufficiently large to account for the death of the animal or to account for the dyspnea which occasionally was noted just prior to death. If the contents of the chest cavity were extracted as a whole and held under water, and air gently forced into the trachea, it would bubble out from the bronchial stump, the healthy lung inflating very slightly. Examination of the bronchial stump showed that the bronchus was wide open, the bronchial tissue distal to the ligature having sloughed and lying loosely attached to the surrounding tissue. Macroscopically, no attempt of bronchial tissue toward healing had been made.

After careful study of the behavior of the bronchial stump after lobectomy, the results following pneumectomy were not surprising.

In our first experiments in this group, the main bronchi was simply ligated, or the bronchial stump crushed with a heavy clamp and then ligated. All the dogs died. At necropsy, it was found that the lumen of the bronchus was gaping. The ligatures had cut through, the tissue distal to the ligature having become necrotic, and finally sloughed.

Results of plastic operation on stump: Next, a series of plastic operations were performed on the stump of the bronchus. The bronchus was invaginated with a purse string, as suggested by Willy Meyer, and the stump was slit and sutured together, mucosa to mucosa, or with the flaps rolled inward and the external surfaces united; and other well known procedures were carried out. Of this group, one dog lived. In that case, the bronchus had been ligated and then the ligated end invaginated by means of two sutures inserted in the bronchial wall in the manner of Lembert sutures. This dog was apparently normal after the tenth day. He was let out of his cage and treated as a pet. Eight months later, following a change of dieners, he ran away. It is of interest to note that during the time the dog was in the laboratory, he seemed to have no respiratory distress whatsoever in spite of his activity. He was apparently in the best of health and was an able and vicious fighter. All the rest of the dogs of this series died, the cause of death being, as before, a wide open bronchus.

Results of dissection and ligation of tertiary bronchi: On the theory that perhaps the difference in our results following lobectomy and pneumectomy might be due to the difference in pressure against the healing bronchus, six pneumectomies in which the smaller bronchi only were ligated, were performed. The hilum of the lung was exposed as before, but instead of the main bronchus being ligated, the lung was dissected away from the bronchial tree until it was possible to ligate tertiary or even smaller bronchi. Then the lung was removed, the stump being left sticking out into the chest cavity like a cock's comb. The first dog survived, and thirty-six days later was killed, and necropsy performed. All the other dogs died, usually about the fifth day. One or

more of the bronchi which had been ligated had sloughed and reopened, with fatal results, as in previous experiments. It was difficult to draw deductions regarding the rôle of the air pressure exerted against the bronchus. Although the total pressure exerted was naturally the same whether the main or the teritary bronchi were ligated, the pressure which each individual healing bronchus had to bear diminished with the increase in the number of bronchi affected and the decrease in the size of the diameter of the bronchi. Pressure evidently was not the impor-

Fig. 5 (Dog 24).—Photomicrograph of the sections shown in part in Figure 4. The cysts, lined by bronchial epithelium and surrounded by displaced bits of cartilage and muscle, were probably mechanical occlusion cysts rather than true cysts which had developed in loco. It was of interest to note the thin tissue layer which separated the lower cyst from the atelectatic lung, and which was plastered over the stump. It indicated that had the lung not been present to occlude the bronchus (as would be the case in pneumectomy), an opening into the pleural cavity might easily have developed. The cartilage was degenerating. The connective tissue in the bronchial wall was but slightly increased.

tant factor in the failure of the bronchus to heal after pneumectomy. The technic of this operation was difficult. Moreover, we found that the operation was not feasible because the bronchial tree divided irregu-

larly, many very small bronchi being given off from the large bronchi immediately after the first division of the bronchus. These bronchi were very difficult to dissect out because of their extremely small size and frailty. In inflamed tissue, it would have been impossible to ligate them.

Results of reducing air pressure by means of muscle implantation with bronchial lumen: Because of these difficulties in technic, and because we were still doubtful as to the importance of pressure as a

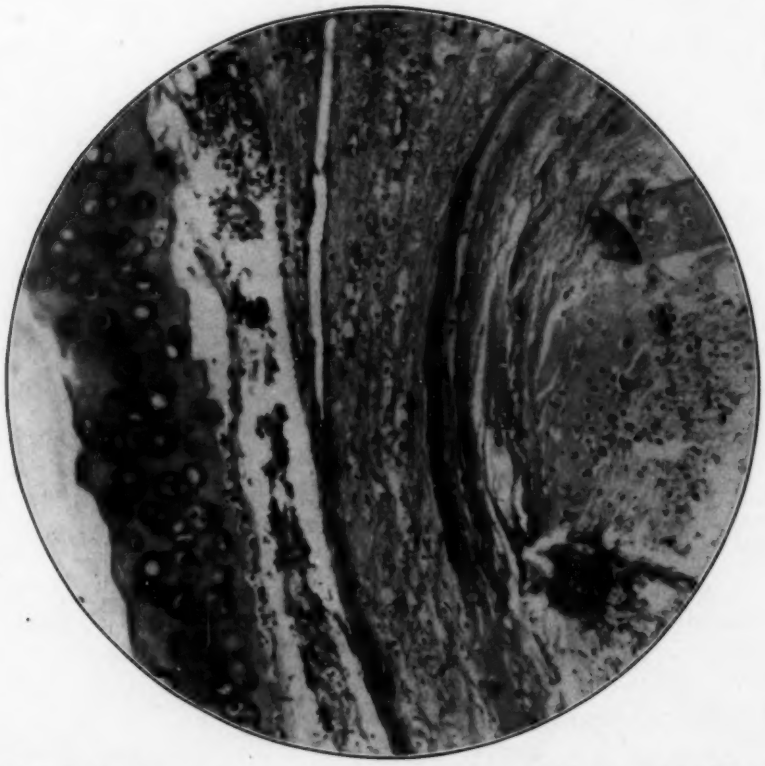

Fig. 6 (Dog 20).—Photomicrograph showing section from closed stump. Ligation of the two main bronchi was performed. One stump was opened on the fifth day, and the dog died. The two sides of the lumen lie approximated. The epithelium is partially destroyed. The wall is edematous. There are evidences of hemorrhage and a large amount of leukocytic invasion. There is no evidence of regenerative activity.

factor in our failure to close bronchi, another series of experiments was performed. In two dogs, large plugs of muscle were taken from the thigh and anchored into the main bronchus just distal to the bifurcation, with the purpose of reducing the pressure in the cut bronchus. The bronchus was then ligated. In the first dog, the primary bronchus was

ligated; in the second, the primary bronchus was slit, the muscle plug inserted and anchored, the bronchus repaired and the tertiary bronchi then ligated. Both dogs died. In both cases, the ligatures had cut through, the distal tissue being necrotic. The muscle plug was found half decayed, only partially obliterating the lumen.

Results after carefully destroying mucosa: As it was felt that the crushing of the bronchi in the previous experiments had not sufficiently destroyed the mucosa, the lumen of the bronchi in several dogs was

Fig. 7 (Dog 11).—Photomicrograph of section from animal which had undergone removal of two middle lobes of right lung. The dog was killed fifty-five days after operation. Closure of the bronchus occurred by means of a very thin lamella of fibrous tissue which was covered internally by a layer of columnar epithelium continuous with that of the wall of the bronchus. The lamella extended directly across from the cartilage of one side of the bronchial wall to the cartilage of the opposite side. The lumen of the distal end of the bronchus formed a dilated pocket. The closure gave the impression of being of a kind which might be easily destroyed by increasing dilatation or by inflammation.

treated by curetting or by cauterization with silver nitrate. All dogs died in the manner described in earlier experiments and from causes already mentioned.

Microscopic study: Sections in these groups of experiments showed a constant inertness of the bronchial wall as far as any signs of repair were concerned. The structures distal to the ligature were necrotic. The structures at the site of ligation seemed to be undergoing a degenerative process. The cartilage invariably stained poorly. The walls were edematous, and in many instances were invaded by pus cells. The fibrous tissue showed hyaline changes. In no section was there any

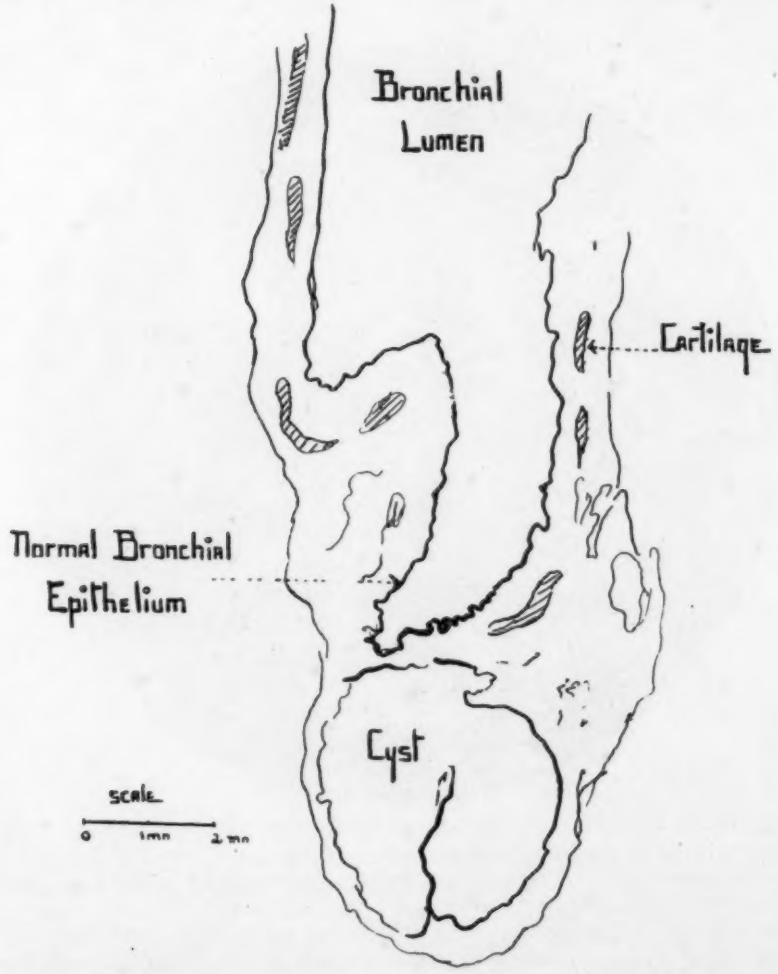

Fig. 8 (Dog 17).—Camera lucida diagram: Pneumectomy of the right lung, with the secondary bronchi ligated. The dog recoved, and was killed on the thirty-sixth day. The two secondary bronchi healed with blunt stumps. The diagram of one stump shows the following: In the occluding tissue is a cyst which contains a few high columnar bronchial epithelium cells. The walls of the bronchus are not greatly thickened. Degenerating bits of cartilage lie in distorted position in the bronchial wall. The thin septums which separate the lumen from the cyst and the cyst from the pleural space may be noted.

evidence of new formation of connective tissue in the walls of the bronchi. In some of the cases in which tertiary bronchi only were ligated, it frequently happened that one or more of the ligated stumps had sloughed, and the dog had died. Sections of these stumps which still held showed the two walls of the bronchus, usually with mucosa denuded, lying in apposition, but as in other sections, no new tissue formation which might result in healing. In the peribronchial tis-

Fig. 9 (Dog 17).—Photomicrograph of second bronchial stump, which showed cyst formation as in the other stump, although the cysts were smaller and there was more connective tissue. It is evident that their presence weakened the bronchial occlusion.

sue, however, there were occasionally found cells suggestive of young fibroblasts.

Sections from the dog which lived showed the following condition: The end of one of the main bronchi was closed off by a very thin layer of connective tissue. A cyst lined chiefly by low columnar epithelium but having a few high columnar cells lay in the terminal portion of the bronchial stump. The lumen of the bronchus was separated from the

cyst by a very thin septum, and only a thin layer of tissue surrounded the cyst. The bronchial wall contained an area of young cellular connective tissue which did not seem to take part in the closure. The other bronchus was closed off by a thicker layer of tissue which contained some cartilage and muscle. The cartilage, which was poorly stained, was evidently degenerating.

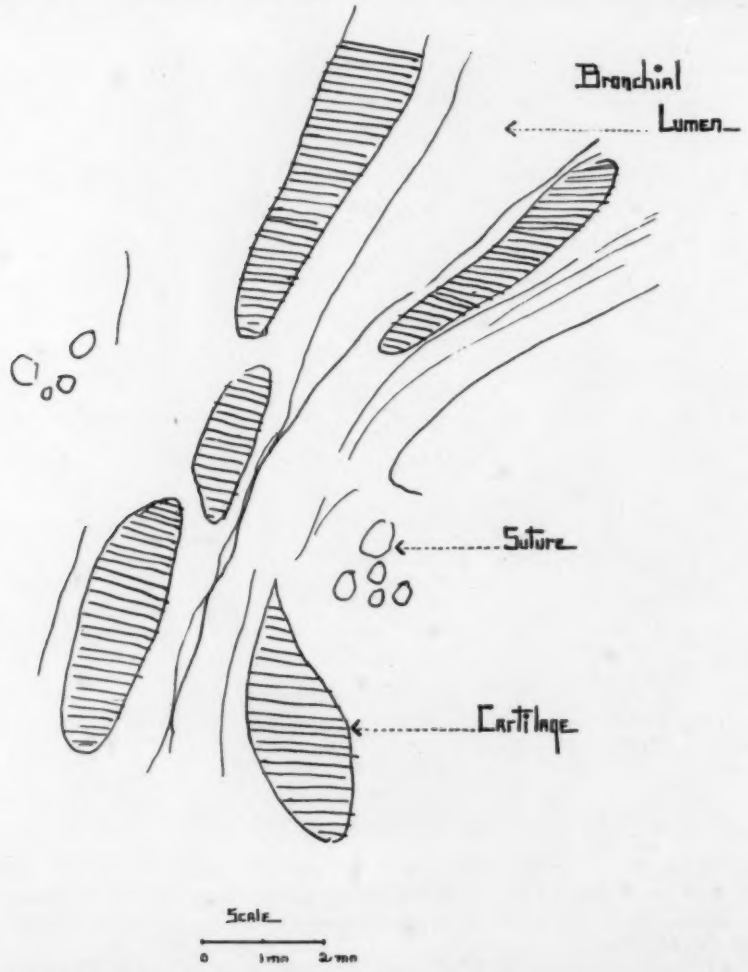

Fig. 10 (Dog 40).—Camera lucida diagram: Pneumectomy. The bronchus was cauterized with silver nitrate. The dog died on the fourth day. The epithelium and subepithelial tissue were destroyed. There was edema in the walls, and many leukocytes were present. Evidently, there was necrosis of the bronchial walls with no evidence of constructive reaction. The sections of the bronchi in which the mucosa was destroyed by curettage were almost identical.

Comment: Thus, the findings in Group 2 correspond to those in the lobectomy group. The bronchial tissue seemed inert, and there

was no regenerative reaction. The peribronchial tissue did show occasional evidences of regeneration. The fact that after lobectomy, the dogs usually lived, while after pneumectomy, they almost invariably died, must be accounted for by the reaction of tissues other than those of the bronchial wall. The remaining lung lobes, in the dogs subjected to lobectomy, were invariably plastered over the occluded stump. From the pleura covering these lobes, much of the newly formed fibrous tissue was derived. It is this extra bronchial connective tissue which effected the healing, and not any of the elements of the bronchial wall. The lung pressing against the bronchus undoubtedly acted as a splint and thus counteracted the air pressure against the healing stump. This splint action, no doubt, was also a factor in repair.

Group 3.—This group included three cases in which the bronchus was ligated and the lung was left in situ. In two of these cases, the ligature had cut through the bronchial wall and the bronchus had not healed; nor had the lung sufficiently covered the opening to prevent the occurrence of pneumothorax. One animal lived, and a necropsy was performed in this case two weeks later. The ligature had cut through the wall and was lying in the lumen. The site of the erosion of the bronchial wall was repaired by newly formed fibrous tissue. The lung was firmly adherent.

Our results have agreed closely with those of Robinson and Sauerbruch, published in 1901.[2] They summarize the literature thus:

> Experimental removal of a single lobe of the lung in dogs is almost always successful. The reverse is the condition following complete extirpation of a lung. Almost all authors report that with the aid of differential pressure, the technique is simple and the immediate mortality low. As far as later results are concerned, there is a divergence of opinion. S. Mayer lost fifteen out of seventeen dogs, Robinson twelve out of fifteen. Tiegel and Sauerbruch report better results, but record no actual figures.

Further in the article, they write:

> The causes of death were many: a few died immediately after ligation of the hilus; some died three days after operation from infection. A third group died on the sixth to the eighth day. These dogs showed a subcutaneous emphysema. At autopsy, it was found that the bronchial lumen was no longer closed but gaping. Death was due to a "Spannungspneumothorax" (pressure pneumothorax) and mediastinal emphysema.

These authors report finding large collections of fluid at necropsy in many of their dogs. This, as I have noted before, we did not find. There is no report of microscopic examinations in this article.

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2. Robinson, S., and Sauerbruch, F.: Deutsch. Ztschr. f. Chir. **102**:543, 1909.

SUMMARY

The pleura of the dog has a strong resistance to infection. Our dogs died from pneumothorax. Infection occurred in but few instances.

The actual removal of a lobe of a lung, or an entire lung, in a dog is a simple operation and easily withstood.

Lobectomy does not kill the dog. The animal survives the operation and within a short time is in as good health as before.

There are no permanent respiratory symptoms following lobectomy.

The cut bronchus heals readily and firmly, but the healing is brought about by peribronchial tissue.

The removal of an entire lung is technically easy. The dogs recover quickly from the operation, but almost invariably die on or about the fifth day.

It is practically impossible to close a primary bronchus permanently; by either simple ligature, purse string invagination or any method we could discover. In two instances, the bronchus did heal. In one of these instances, it healed by means of a very thin bridge of connective tissue, which evidently could offer no resistance to increased pressure or to infection.

The bronchial tissue itself did not seem to undergo regeneration.

In one case the peribronchial tissue closed the bronchus. Our dogs usually succumbed to pneumectomy on about the fifth day, owing to the fact that the cut bronchus reopened and a pneumothorax resulted.

In short, it seems evident from our experiments that, in closing a bronchus, we have to deal with difficulties, due to the inherent inertness of the bronchial wall tissue, which refinement in technic cannot hope to overcome.

In order to close the bronchus, we must be able either to stimulate the bronchial wall tissue, or to transplant from elsewhere tissue which will react. It appears to us much more profitable to direct our energies to combating the symptoms produced by the opening of the bronchus a few days after lobectomy or pneumectomy, as is being done clinically.

DISCUSSION ON THE PAPERS OF DRS. CARL A. HEDBLOM, WILLY MEYER AND RALPH BOERNE BETTMAN

DR. W. S. LEMON, Rochester, Minn.: I had the privilege of seeing all the cases in which operation was performed and it might be of interest to you to know what the end-results were from a medical standpoint. Physical examination has just been completed on these patients, who have been good enough to make this demonstration possible. The evidence of fibrosis has been definitely present in every case, as the heart is transposed to the side operated on. The trachea likewise is drawn to the affected side in each instance. Spinal curvature of greater or less extent is usually seen and is present in these patients. The convexity of spinal curvature is always toward the sound side. I have seen

only one instance in which this was not true, and that was complicated by poliomyelitis, with an unequal reduction in the strength of the muscles of both sides.

The evidence of emphysema is present in every case, and in one instance is of such degree that the sound lung passes across the mediastinum, occupying part of the area formerly filled by the diseased lung, thus compensating for the disability produced by its collapse.

In each case presented today, there has been no loss of strength in the abdominal muscles. This is a condition one has to anticipate in operations on the chest. Definite atrophy may appear in the rectus muscle, producing loss of strength and tone and bulging of the abdomen on the affected side.

One of the patients shown still uses gravity drainage. We use exactly the same type of drainage that has been described by other members of the society this afternoon.

Clubbing of the fingers is present in each instance, but in none were bony changes found. Therefore, reduction in the clubbing can be noted following operation and was to be expected. In the series of cases which I reported to the association last year, actual bony changes had appeared, and in the subsequent course, these changes could not be expected to disappear following operation.

The frequency of hemorrhage in such patients is noteworthy, although the hemorrhage is rarely a profuse one. In our experience, tuberculosis probably takes first place in the production of hemorrhage; conditions of the heart such as mitral stenosis, second; abscess of the lung, third, and bronchiectasis, fourth. The bronchiectatic hemorrhage not only is smaller in amount, but usually the blood is intimately mixed with the sputum so that it takes on a salmon color.

One interesting point in the examination of the young girl whom Dr. Hedblom has presented is the fact that she had a unilateral bronchiectasis. Our figures on the affection of the two sides are about the same as those of other men, namely, about 35 per cent. of our bronchiectasis cases are unilateral. In the examination of this young girl, the heart sounds are very materially increased throughout the whole left side at the present time and have taken a high pitched, metallic tone. One may speculate on the cause of this, going back to the physics of sound production, recalling that the reflection of sound is influenced by the type of tissue through which it must pass. There is in these fibrosed lungs a uniform type of tissue which is designed to carry sound particularly well and without loss from reflection. After the collapse of the lung and the shortening of the bronchi, the high pitched overtones predominate and this explains, in this case, the presence of the metallic sound that was heard throughout the chest. On first examination, the findings were confusing, because the sounds might have been confused with intrapulmonary râles. However, when the patient held her breath, it was clearly shown that this was not true, but that the sounds were due to the heart sounds themselves, carried through the fibrosed lung to the ear.

Dr. Edward W. Archibald, Montreal: This problem of bronchiectasis is a most pressing one to us all, particularly the problem of high mortality from lobectomy. We are all seeking a way to reduce that mortality. Dr. Meyer, in a recent article, advises us to stick to Dr. Lilienthal's technic, which has reduced the mortality to 45 per cent., and he calls that a "truly splendid achievement." I quite agree with that from the surgeon's point of view. But, if I have to say to a patient that he runs a fifty-fifty chance of dying from the operation,

he is not likely to consider the achievement as so very splendid after all. I realize perfectly that to reduce the mortality much further is going to be a big problem, and one that will need many years of work.

May I now report a recent case successfully treated by lobectomy under a method by which we may probably reduce the mortality. I confess at the start that it was a comparatively easy case. A girl of 12 years, who swallowed a button four years previously, gradually developed a great deal of foul sputum, which she coughed up in large quantities for two years. She then coughed up the button. She went on coughing for the succeeding two years; had a temperature of from 99 to 100 F., a pulse of from 90 to 100. The sputum measured from 16 to 18 ounces (473 to 532 c.c.) a day and was very foul. She was somewhat cyanotic. Obviously, she was chronically toxic. The roentgenogram revealed a typical picture of bronchiectasis in the right lower lobe. The patient was quite unfitted for school life. Her future was blighted, and the question was what was to be done. Following Dr. Meyer's advice of the last two years to refer such cases to a bronchoscopist for investigation, and, if possible, treatment, the child was referred to Dr. Birkett for bronchoscopy, which was performed under an anesthetic for the first time. She gradually got used to the passage of the bronchoscope as far as the throat, but would never allow it to go further. Bronchoscopic treatment had to be given up. Thoracoplasty alone I had discarded because of an unsuccessful result two years ago, an experience confirmed by Dr. Meyer and others. (I am inclined to change my mind in this respect now since hearing Dr. Hedblom's paper.) Dr. Lilienthal's one-stage lobectomy carries a forbidding mortality. What are the dangers of this operation? They are first, infection, either of the pleura, or of the mediastinum through the stump, and secondly, shock and tension-pneumothorax. We can obviate at least two of these, infection and pneumothorax, by getting the stump of the lobe outside of the external wall and packing it off. Dr. Lilienthal reports in his paper that Garré suggested this method of exteriorizing the stump. I have not been able to confirm this statement in Garré's book. But the main point of this plan is that it is absolutely necessary to get the stump outside the chest wall. If this can be done, one can pack off and be sure of getting neither empyema nor a tension-pneumothorax. By steadying of the mediatinum, mediastinal flapping is avoided. If the stump ligature does give way, air does not enter the closed chest; it comes outside. Dr. Bettman's paper again emphasizes that. The question is how to get it outside. That can only be done by an extensive preliminary thoracoplasty, and that is the plan I would propose and which I carried out. The result has been perfect so far. As to the technic, I removed from the tenth up to the fifth rib, inclusive, posteriorly. This, however, as I found, is not sufficient; the fourth, third and second still hold the chest out and prevent thorough falling in of the wall. One must take these off in a second stage, and also extend the resection from behind the angles well into the axillary line. Nevertheless, I was able to get the stump far enough into the wound that its outer end projected on the skin level, while its base lay about the level of the parietal pleura. It was anchored with silk sutures passed through the skin away from the wound edge. Gauze packing was placed around the stump, and the rest of the wound was sutured. Meyer's air tight drainage was established through a separate stab in the ninth space, and the whole side of the chest was sealed with dental rubber. There was no particular disturbance of respiration, and no infection of the pleura occurred. The patient began to convalesce perfectly from the start and is now, after two months, entirely

well, save for the inevitable bronchial fistula which we expect to granulate over in time. Her sputum measures from one half to 1 ounce (15 to 30 c.c.) in twenty-four hours, and is clean.

Dr. Howard Lilienthal, New York: Lobectomy is certainly necessary in some cases, but it should be reserved for the chronic cases or for those in which there is rapid extension. Supposing that the mortality rate is 50 per cent. —it is probably more—there is still no reason for the medical practitioner's great objection to the operation. The mortality of operation in cases of cancer of the stomach, if the figures of certain of the large clinics may be excluded, is well over 50 per cent., but physicians have become accustomed to that. They regard a case of cancer as a case for the surgeon, and yet in advising surgery for the incurable lung condition they are timid.

The quantity of sputum per day may greatly diminish after palliative operations and the satisfaction of the patient with his condition depends largely on his individual character. The reduction of the amount of sputum from, say, 800 c.c. a day to 75 c.c. should bring the patient to realize that he is greatly improved, but this is not always the case. Some patients are difficult to satisfy. Dr. Hedblom's patient has every reason to be gratified at such a good result. An analogy between this collapse operation for the cure of bronchiectasis and that for the cure of tuberculosis can hardly be drawn. In tuberculosis, it is rest for which we strive. In bronchiectasis, it is drainage, whether this drainage is external or by mouth. The reduction of secreting surface accomplished by collapse therapy is a great aid. In tuberculosis, extrapleural thoracoplasty does more than any other therapy to place the lung at rest. There is usually great improvement with arrest of temperature. The same or a similar operation in bronchiectatic cases has not, in my observation, been so successful. After seeing Dr. Hedblom's cases, I am afraid I shall follow his lead and make other attempts in some of these cases to relieve the patients by extrapleural surgery, especially in those cases which are not suitable for lobectomy.

In speaking about cough, Dr. Lambert stated that the external opening of an abscess destroyed the power of coughing. It is true that the actual physiologic cough is not possible in the presence of a bronchial fistula, but the expulsive efforts of the patient discharge material through the mouth and through the wound. Besides, as Dr. Meyer has shown, an open bronchus aids pulmonary aeration, and aeration of parts of the bronchial tree that cannot otherwise be reached is almost as important as drainage.

I am glad that Dr. Bettman's paper was presented. His reasons for the refusal of a bronchus to heal are perfectly sound. Openings in small bronchi, however, while their walls do not adhere may still close by granulation.

Dr. J. J. Singer, St. Louis: No one has mentioned or suggested a line of treatment which Dr. Graham has recently started in some of our lung abscess cases, and I desire to mention it because he is not here, and to have it go on record; and that is lobectomy with the cautery, suturing the pleura to the chest wall after preliminary removal of two or three ribs, and then with the cautery, three or four or five days later, using the ordinary soldering iron, keep on burning and burning without reaction on the part of the patient, with brilliant results so far as the removal of infected foci is concerned. Dr. Graham is not here to speak for himself. He has done that in five cases. None of the patients are completely cured because of the slow process, but it is remarkable when you stop to think of lobectomy and the results and the reaction. Here, there is no reaction. The patient does not know it. It is done without an anesthetic and the patients go about their affairs.

There has not been a hemorrhage in any of these cases. Dr. Graham said, in his work, that the pressure in the vein or pulmonary artery is so light you cannot get much hemorrhage.

Dr. Edward W. Archibald, Montreal: I should like to ask Dr. Hedblom if the prolongation of the rib resection far forward brings about any great increase in the amount of lung compression obtained. We are accustomed, in extrapleural thoracoplasty for tuberculosis, to obtain about 50 per cent. reduction of the chest volume on one side; and from photographs we see that the side flattens right down. That is the only point, so far as I can see, in which Dr. Hedblom's technic differs from that of others who have performed thoracoplasties for bronchiectasis, usually with unsatifactory results, and it might account for the improvement in his results. Naturally, in so extensive a rib resection as he has described, his method of grading it is an excellent safeguard, and represents a principle which we must take to heart. His results exceed anything yet published.

Dr. C. A. Hedblom, Rochester, Minn.: Spontaneous cure of pulmonary abscess does occur, and I agree that if the patient is in fairly good condition and definitely and progressively on the mend, expectant treatment should be employed. But I am not so optimistic as some, perhaps because 75 per cent. of the patients with pulmonary abscess I see represent the failure of such treatment. Many of these patients present themselves with large or multilocular cavities, with more or less secondary bronchiectasis and with the anemia, wasting and edema of a chronic suppurative process. The high operative mortality in such cases should, it seems to me, be credited to the earlier expectant treatment. Could this be done, it would serve as a check against an overenthusiastic use of expectant treatment.

With regard to the treatment of bronchiectasis, I wish to state that lobectomy appeals to me as theoretically the surgical procedure of choice, just as nephrectomy is the rational treatment for pyonephrosis. But, so far, the mortality has been very high and the percentage of cures low.

When I began to perform these thoracoplasties, it was with the idea of performing lobectomy later, but, so far, all patients have been so much improved by thoracoplasty that lobectomy was no longer indicated.

Dr. Willy Meyer, New York: Before closing the discussion on my own paper, I should like to ask Dr. Hedblom a question. He referred to cases of "typical bronchiectasis" as suitable for the plastic operation and mentioned the case of a girl who had had influenzal pneumonia. Is that correct?

Dr. Hedblom: Yes.

Dr. Meyer: It is my belief that we have to differentiate our cases according to the particular type of suppuration we have to deal with. The suppurative affection of the lung, described years ago by Tuffier, represents what I would call "typical bronchiectasis," where evidently congenital malformation of the lung plays an important etiologic rôle. To my mind, that type of suppuration in which the divided lung looks like a bunch of grapes cannot develop after aspiration of a foreign body or a foreign substance, nor subsequent to pneumonia or influenza.

Dr. Hedblom: The roentgenogram of the tissues shows a translucent chest cavity with a little peribronchial infiltration and thickening. We made a diagnosis largely on the abundance of the sputum.

Dr. Meyer: We are still in the infancy of this chapter, and everybody interested should relate his clinical experience and try to explain what he has seen. To me, it seems wise to differentiate suppuration of the lung as typical

bronchiectasis, bronchiectatic lung abscess, and typical lung abscess as it follows acute or subacute pneumonitis. At first, there was a tendency to include all pulmonary suppuration under the name of bronchiectasis. But this caused considerable confusion. I was glad to hear Dr. Hedblom's paper. In former years, I performed extrapleural thoracoplasty for suppuration of the lung eight or ten times. While I have greatly improved a number of the patients, I did not cure any of them. Some of them died. To my mind, the reason that Dr. Hedblom has achieved such success in the patient presented is that he did a more extensive resection of the chest wall, a combination of Sauerbruch's and Wilms's operation; in other words, a complete excision of the ribs.

I have combined ligation of branches of the pulmonary artery with the extrapleural thoracoplasty. That is what Sauerbruch originally proposed. I have done it three times with recovery of the patients from the operation. It is a comparatively simple procedure. If one is careful and gets well between the lobes, the lung will not tear. We must remember that the artery lies cephalad to the bronchus and the vein opposite it: In one of my cases, only ligation was performed, and the patient was so well satisfied later on, that rib resection did not seem indicated.

The tendency nowadays is toward conservatism in these operations, and rightly so. Yet we must not forget the fact that, if a patient is not satisfied with the result obtained, resection of the lung is indicated. I believe that prolonged intrabronchial treatments will in many instances help the patient immensely. It will be wise to combine it with the postural treatment twice, or, better, three times, daily. In this way, we may obtain more satisfactory results, and obtain them more quickly.

Dr. Bettman's work is very laudable. If I understand him rightly, he crushed the base of the bronchus in his animal experimentation for lobectomy and then ligated it. Inversion of the crushed bronchus plus suturing insured primary union of the bronchial stump, as we performed it fourteen years ago, at least in the experiment. It seems to me that, at the present time, surgeons will do best to follow Dr. Lilienthal's technic in extirpation of the lung, because he has had a lower mortality in excision of the lung than any of us. I think his mortality was not more than 45 per cent.

Dr. Lilienthal: It is more than that now.

Dr. Meyer: Let us then say 55 per cent. Even at that, the showing is excellent. There are many cases calling for extirpation of the lung. Therefore, the operation must be done. But it must be perfected and made less dangerous. This problem will probably be worked out in the near future on different lines, and by members of this Association. I think that our original experiments made on dogs, crushing the main bronchus at its base (in the sick human being, after primary compression of the pedicle and amputation of the lung, and thorough disinfection of its diseased mucosa) and then closing it by a mass ligature, or by inversion plus suture, or by fastening some retained piece of the tissue of the lung on top of the stump, will prove another good, perhaps safer, method that may be resorted to. I cannot help thinking that perforation of the bronchial stump with its large blood-vessels by a sharp needle and thread may at times be the direct cause of late hemorrhage, and a fatal issue.

If Dr. Archibald's method of placing the bronchial stump outside the chest cavity proves satisfactory, it will mean another step forward. When this procedure was combined with thoracoplasty at a second stage, the resulting cavity would be made to shrink more quickly.

Lately, we had a most interesting case of suppurating lung at our hospital. A woman, 26 years of age, had been perfectly well until her tonsils were removed. Pulmonary suppuration developed. When seen, she had a high fever. We advised bronchoscopy and, if necessary, later on operation. It was found that she had an abscess in the lower lobe of the right lung. After months of faithful intrabronchial work, we had to operate. We entered a cavity posteriorly, which was filled with an accumulation of foul-smelling fibrinous coagulated material, probably remaining from a local gangrene of the lung tissue. We tried to keep the abscess cavity open, striving to establish a lung lip fistula for prolonged drainage and ventilation. But nature closed it prematurely. Again fever with increased expectoration set it. Seven months later, Dr. Pickhardt performed a second operation, laying open the original cavity, with a larger one above, of hour-glass shape. Again the patient improved materially, the fever and sputum disappearing. Suddenly, while sitting in the garden one day, she felt chilly. Another recurrence of the disease set in. Six months after the second operation and repeated transfusions of blood, we operated for the third time, under local anesthesia, and exposed completely the entire diseased lung area. We had to disregard precaution against hemorrhage and divide the lung deeply with the cautery, making a true section cut as we do in the kidney. Now all secretions, we thought, must drain into this wound. Drainage was prolonged, but the patient coughed and coughed, raising plenty of sputum, evidently from a focus with poor direct communication with the wound. At last, expectoration ceased completely. I shall never forget the patient's happiness when one morning she reported "Doctor, I have not expectorated for the last two days; I feel fine." We all shared her rejoicing. Then we ordered what she had received twice before, a transfusion, considering it desirable to give her additional new material to burn. She had the same donor she had had twice before, but a few moments after the transfusion had been started, she complained of intense pains throughout the body. Our serologist stopped for a while and then continued. The patient received 300 c.c. of blood in all. She had very high fever the night following. The next morning she was still feverish, but improved, and still complained of intense pains. While on the ward, I was called by the nurse, as the patient seemed to be dying. A sudden change for the worse had occurred; her pupils became widely dilated, and in a short time she died.

Postmortem examination disclosed pulmonary embolism and a cylindrical cavity in the lung, near the large wound, which had completely emptied its contents by increasing direct communication, the true picture of a quieting-down volcano. How that embolism developed, I shall not take time to discuss here. I will only say that we believe it had formed since the transfusion was given. Probably, a thrombus had been dislodged from the bronchial vein and was driven into the right side of the heart, where it had quickly enlarged, and then entered the pulmonary artery. It was round, and blocked the lumen completely.

I would utter here a note of warning: after we have achieved a certain goal, we should be satisfied. Had we not attempted to do more, our patient might have lived. In conservative work, patience and perseverance must remain our watchword to the end.

Dr. R. B. Bettman, Chicago: In answer to Dr. Meyer, I wish to call attention to a series of dogs in my experiments in which the bronchi were carefully crushed by means of various types of crushing instruments. All dogs

in this series died. I am exceedingly sorry that Dr. Heuer was forced to leave early. His reports are at variance with mine. Most of his dogs lived, according to his writings, and I should have liked to hear his explanations as to why the bronchial stumps did not reopen.

With reference to what Dr. Archibald and others have said, bronchi, that is large bronchi, cannot be artificially closed. Nature does close them, but slowly, after a long period. I think the explanation of this lies in the fact that the bronchial tissue itself has little healing power, and the eventual closure results from peribronchial tissues.

bacillus, were the only bacteria found, and that sixteen months later, after the patient was apparently well, another pulmonary abscess developed in the right upper lobe, from which the identical two organisms were again the only ones isolated, at a second operation.

We have attempted some preliminary experiments with monkeys in an endeavor to produce lung lesions by intratrachial injection of these anaerobic organisms, and in one monkey this was done in conjunction with tonsillectomy. The animals reacted with some fever for a few days, but no lung lesions were produced.

We shall continue this study, as it appears to us to have an important bearing on the subject.

The fact that some of these anaerobes correspond to the type found in the mouth and throat in such conditions as pyorrhea and Vincent's angina raises the further interesting query as to whether the well recognized relationship between pulmonary abscess and operations on the upper air passages may not, in part at least, be due to the pathogenic possibilities of these anaerobic bacteria in producing abscess when they reach the lung under the varying conditions of the inspiration of foreign infected material at the time of operation.

METHODS OF TREATMENT

The cases of this series, with four exceptions, have been studied jointly from the medical and surgical points of view, the hospital cases which compose the larger part being the subject of a medicosurgical conference held at least once a week during the entire period of their observation. This, we believe, is the ideal method of investigation.

Originally, we approached the problem of their treatment as primarily a surgical one, and in the earlier part of our studies, we were inclined to advocate operation as soon as the diagnosis was accurately established. These operations were performed independently of the age of the patient, his condition or the type of lesion present. The results were most disheartening, and consequently, about one year ago, we changed radically our procedure by treating these as primarily medical cases, advocating operation only after medical treatment had failed or after the local conditions for successful operation had become more favorable.

The medical treatment consisted of rest and postural drainage, the latter carried out regularly four or five times a day for periods varying from five to twenty minutes each.

Postural drainage is carried out by the patient hanging over the side of the bed with the head to the floor. This position is maintained for from three to five minutes at first and is repeated four or five times a day. As the patients become accustomed to the maintenance of this posture, the time is increased to as long as may be necessary to empty

the abscess cavity thoroughly. This is usually not more than fifteen or twenty minutes for each drainage, and is frequently less. The patient soon comes to recognize the period desirable to his individual case, and also can appreciate the need for the repetition of the procedure by the returning tendency to cough and expectorate. When successful, this method affords several hours of almost complete freedom from cough and expectoration, and is accompanied by marked diminution in the constitutional symptoms and, after a few days, by a gradual diminition of the total quantity of the expectoration as well as of its fetid purulent character.

We believe that by this method it is possible to increase very materially the number of cases which may be cured by spontaneous drainage through a bronchus. It also will aid in diminishing the extent of the area of inflammatory reaction in the lung surrounding the abscess and will improve the general condition of the patient, rendering the case more suitable for operation should this become necessary.

The surgical treatment consisted in the main of incision and drainage in one stage if the pleural cavity was walled off by adhesions. Otherwise, there were two stages. Local anesthesia is certainly safer than general anesthesia even with nitrous oxid gas and oxygen. A soft rubber dam is the best form of drain, and we have abandoned the use of gauze, employing it only to control hemorrhage. We found this operation extremely dangerous and usually unsuccessful in the acuter phases of the disease; that is, during that period when there was present about the softened central suppurating focus a more or less extensive zone of edematous, soggy, infected lung in which the smaller bronchi were filled with pus and the alveoli were distended with seropurulent exudate, while the walls of the alveoli were swollen and edematous. None of these cases were seen prior to rupture and establishment of communication with a bronchus.

Our experience has led us to believe that incision of the abscess at this time fails to drain effectively the entire infected area, and that, with a free opening established, the effectiveness of coughing in emptying these areas is greatly reduced. In many of our cases in which the abscesses were opened during this stage, there was a pronounced improvement for a few days; the expectoration was diminished; the temperature became normal, and the patient apparently was making a satisfactory recovery. But this period was followed by a wide extension of the pneumonic process, sometimes ushered in by a chill and a fatal termination in from three to five days or a week. At necropsy, there was found a wide-spread massive involvement of the entire lung or both lungs, in which the bronchi were filled with pus and the alveoli either showed the changes of an acute pneumonia or

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were swollen, edematous and infiltrated with leukocytes. In some cases, there were multiple small abscesses widely disseminated throughout the lungs.

After postural drainage, even if it does not effect a cure in itself, there is usually a definite improvement in the constitutional symptoms and a clearing of this secondary zone of infiltration about the abscess, which renders an operation much more liable to succeed.

There is a period in lung suppuration when the alveoli in the immediate vicinity of the abscess are collapsed but the respiratory epithelium is still intact, and they are therefore capable of reaeration; and this is the most favorable time to operate.

If the suppuration continues, this epithelium disappears and the alveoli are obliterated; and there is found a true connective tissue layer composed of the fused alveolar walls, observed in chronic abscesses: a condition most unfavorable for a complete cure and one which favors the establishment of a permanent bronchial fistula.

The problem is to give each patient an opportunity to reach this more favorable stage and at the same time not allow the disease either to go on indefinitely or to drift into the chronic abscess with thick fibrous walls, which is unfavorable for radical cure by operation or any other method of treatment.

This can be done only by the close cooperation of physician and surgeon in the study of the case, and particularly the comparison of frequent roentgenograms of the chest.

From three to four weeks of such medical treatment may usually be safely employed to determine the necessity for operation, in which time many will recover without it.

More radical operation in the form of lobectomy, although successful in one of the three cases in which it was attempted in this series, must still be considered an extremely hazardous procedure, although theoretically it might be considered the ideal treatment when, by an improvement in surgical technic, it is possible to diminish the present great operative risk. The successful case was one seen by Dr. Miller. The lobectomy was performed by Dr. Lilienthal, who obtained a brilliant result.

Artificial pneumothorax is being quite extensively advocated for the treatment of acute pulmonary abscess. Our experience has been very limited, it being used only in the case of seven patients, none of whom improved and two of whom died.

We do not wish, however, to have this considered our final judgment on this method of treatment; for it seems quite possible that it may be of help in acute abscesses freely opening into a bronchus and situated near the hilum of the lung.

We do wish to emphasize that its use in peripheral abscesses is attended with great danger of rupture of the lung, with subsequent pyopneumothorax. This actually happened in two of our cases, and has been quite frequently reported in the literature. Also, it is our experience that this method may do harm in the case of abscesses not situated near the hilum by exerting pressure on the proximal portion of the bronchus and thus shutting off drainage; and it also may inhibit drainage by preventing the normal expulsive power of coughing. In one case, we employed this method very successfully for the control of large and repeated hemorrhage.

BRONCHOSCOPIC LAVAGE

Bronchoscopic suction and lavage has also been very favorably advocated in the treatment of pulmonary abscess. Our experience has been limited to three cases which were referred to the laryngoscopic division of the hospital for this treatment. In these three cases, one patient was improved, one not improved, and one died, apparently from a rupture of the lung directly following the treatment. We have no desire to record a final judgment on this method from our scant experience; and bronchoscopic examination is highly to be recommended in cases of suspected foreign body in the lung, and for diagnosis.

We are impressed with the fact that this procedure is a very trying ordeal for acutely ill patients, and we are not convinced that it is unattended by a real risk to the patient.

ANALYSIS OF CASES

Sex.—Forty-five cases were in men and fifteen in women, a proportion of 3 to 1. This is in accord with the reports of other observers.

Etiology.—The cause of pulmonary abscess in a given case is not always easy to establish. As far as we could determine from the histories, the etiologic factors in this series may be grouped as follows: no definite cause (primary abscess), 22; secondary to pneumonia, 16; secondary to postoperative pneumonia, 3; secondary to tonsillectomy, 8; secondary to other operations, 5; following tooth extraction, 2; following submersion, 2; following foreign body inhalation, 1; following trauma to chest, 1; total 60.

The high incidence of cases (36.6 per cent. of all) to which no definite primary cause may be ascribed is noteworthy; also the occurrence of abscess following tonsillectomy is lower than in many other series reported.

Duration of Disease.—The duration of the disease before coming under observation is important from the standpoint of methods and results of treatment: less than one month, twenty-three cases; from

one to three months, twenty-three cases; from three to six months, seven cases; over six months, seven cases. Forty-six of these cases (76.6 per cent.) may therefore be considered as acute abscesses.

The results of treatment show that in the twenty-three cases of less than one month's duration, fourteen patients (60.8 per cent.) were cured and five died, a mortality of 21.3 per cent. In the twenty-three cases of from one to three months' duration, six (26 per cent.) were cured and nine (39 per cent.) died. In the seven cases of three to six months' duration, two (28.5 per cent.) were cured and three (42.8 per cent.) died. In the seven cases lasting more than six months, three (42.8 per cent.) were cured and three (42.8 per cent.) died. The generally recognized predominant importance of early treatment is again emphasized.

Location of the Lesion.—The lesions were in the right lung in forty cases; in the left lung in nineteen, and in both lungs in two cases. They were in the lower lobe in forty cases; in the upper in nineteen cases; in the right middle lobe in one case, and in both upper and lower lobes in one case. In three cases, there was multiple lobe involvement.

In the nineteen upper lobe cases, ten patients (52.6 per cent.) were cured and six (31.5 per cent.) died. In the forty lower lobe cases, sixteen (40 per cent.) were cured and twelve (30 per cent.) died.

These results indicate a somewhat more favorable prognosis in upper lobe cases, but not so favorable as in some other series.

Results of Treatment.—As has already been described, our experience led us to modify radically our methods of treating these cases.

We are therefore reporting the results in one series as a whole and in addition are reporting separately the comparative results obtained by the two radically different methods, as shown in the accompanying tabulation. These results are indicated by an early series of twenty-nine cases in which early radical surgery predominated and a later series of thirty-one cases in which medical treatment was almost invariably first tried, with postural drainage as the most important feature.

Results of Complete Series.—60 cases; cured, 26; improved, 6; unimproved, 8; died, 20. A mortality of 33.3 per cent.

Results of Early Series.—29 cases; cured, 11; improved, 2; not improved, 4; died, 12. A mortality of 41.4 per cent.

Results of Later Series.—31 cases; cured, 14; improved, 5; not improved, 4; died, 8. A mortality of 26 per cent.

The comparison not only shows the later series to much better advantage in increased cures and diminished mortality, but also indicates a larger number who were improved, although not cured, the combined cured and improved patients being 45 per cent. in the early series

and 61 per cent. in the later one. The fact that by medical treatment a certain number of patients were able to go on fairly comfortably without constitutional symptoms and with alleviation of disturbing cough and expectoration influenced not a few to decline advice to undergo an operation, advocated in the hope of effecting a radical cure.

Results Obtained by Various Methods of Treatment.—In comparing the two major therapeutic procedures which we have employed in this series, we find that postural drainage was used in thirty cases, in which fourteen patients (46.6 per cent.) were cured, four (13.3 per cent.) were improved, eleven (36.6 per cent.) were unimproved and one patient (3.3 per cent.) died.

In the operative cases, of which there were twenty-seven in all, eleven patients (40.7 per cent.) were cured; one patient (3.7 per cent.) was improved, and fifteen patients (55.6 per cent.) died.

The higher mortality in the operative cases is very striking, although it must be borne in mind that there are here included eight cases in which medical treatment had first been tried and had failed.

It also must be noted that the operative results in the later series, in which we had arrived at a more satisfactory method of selection of cases as regards the time most suitable for operation, are much more favorable than in the early series. In fourteen operative cases of the early series, the mortality was 71.5 per cent.; while in thirteen cases of the later series, it was only 38.5 per cent.

SUMMARY

1. Acute pulmonary abscess is a comparatively common and extremely serious disease.

2. There is a great opportunity for improvement in methods of treatment. This can best be met by close, combined study of each case by physician and surgeon.

3. It seems probable that many abscesses are not preceded by pneumonia.

4. Our studies of the bacteriology would indicate that anaerobic micro-organisms may play an important pathogenic role in their causation. Further study of these organisms seems important.

5. The treatment of acute abscess is primarily a medical problem. When surgery is necessary, results are far more successful after preliminary medical observation and treatment.

DISCUSSION

DR. JAMES ALEXANDER MILLER, New York: We have been greatly interested in attacking and studying this together as a joint problem. The results are not very good, but no one is more cognizant of that than we are.

In justice to Dr. Lambert, I wish to say that these are all the cases that came in; they are all reported, whether medical or surgical, the unfavorable and the

favorable. The paper does not present any particular method of treatment, but considers the whole question of what may happen in pulmonary abscess. If you take the statistical records of any hospital, you will find that the mortality ranges from 35 to 50 per cent. Many of these patients that Dr. Lambert operated on were extremely ill on admission, and the mortality was staggering. In presenting this problem, we want to suggest that one does not lessen the possibility of surgery by giving postural drainage a four or six weeks' trial. One can tell within a week or ten days whether the cases will improve under this treatment or not. Then if you have to operate, you have probably improved the chances of success rather than diminished them.

As to the question of getting better results, we are getting much better results this year than we did last, as we continue to learn more about the subject; and therefore we feel that possibly in another year we will be able to get still better results. A point I should like to emphasize is the value to the intern of studying these cases regularly, periodically and systemically from both the medical and the surgical point of view; and that is what has been done in all of our cases.

Dr. J. J. Singer, St. Louis: The medical side of this problem has been taken up by myself and the surgical side by Dr. Graham, and I want to say that both of us are in constant attendance on the patient. It works very well.

I submitted a paper by Dr. Graham and myself on abscess of the lung and the results and general outline of treatment agree very well with those that Dr. Miller and Dr. Lambert have presented. Our figures are very close to theirs. We report thirty-four cases and they sixty.

The acute abscesses we have had usually followed tonsillectomy. Eight out of the thirty-four cases were due to tonsillectomy and three to other operations, as, for instance, herniotomy.

Postural drainage, I believe, promises much. I have seen many cases. I recall one that taught me a lesson which I have not forgotten. About five years ago, a patient who had a tonsillectomy developed fever and chill ten days after operation. I was called because he had a severe pain in the side, which was thought to be pleurisy. On careful examination, it was found that a post-tonsillectomy abscess was developing. After five or six days, the physical signs pointed to a localized upper lobe abscess. Five years ago, we did not know a great deal about abscess of the lung; we do not know much about it yet. At the time, there was some question about putting a needle into the abscess or trying to find it with the needle. We are not so likely to do that today. I was told after consultation with several of my colleagues to put a needle into the second interspace. I did and got a dry tap. I inserted the needle in three or four places, and did not find anything. We did not find the abscess until three or four weeks after postural drainage. I think that 90 per cent. of these cases tend to clear up in a week or ten days.

I believe the time of operation is very important. Dr. Miller brought out clearly the fact that there is a pneumonitis around the abscess. It is evident that most surgeons wait for the abscess to become ripe, and that is the time to operate. Otherwise infection is spread throughout all the bronchi and the lungs in general.

Dr. Nathan W. Green, New York City: It is well to withhold surgery until such time as the patient shows at least a stationary period in the disease, if not an improvement. I have had a few cases of lung abscess in the last few years, and a few of the patients I have advised not to be operated on. Dr. Le Wald and I have observed them together. One or two cases were so ful-

minating, with disseminated infection and destruction of tissue, that the patients did not show the period of improvement anticipated, but grew steadily worse and were very sick. Operation would have been fatal. Dr. Lambert points out the fact that it is well not to subject an almost moribund patient to surgery. We must bear that point in mind in studying our cases in the future.

Dr. Leon T. Le Wald, New York: I should like to add a word or two as far as classification of these abscesses in concerned. I refer to latent or quiescent lung abscess.

In two recent necropsies at St. Luke's Hospital after surgical operation, the cause of death was found to be a small abscess of the lung, lower lobe, with a surrounding acute bronchopneumonia. Both of these cases would have been put down as surgical deaths probably if necropsy had not been performed. As a word of caution, it is well to anticipate anything of this sort by a careful roentgen-ray examination of the lungs prior to any surgical procedure. That was not done in these cases. One was a gastric case, and the other a duodenal ulcer.

Dr. Willy Meyer, New York: Teamwork in cases of abscess of the lung is certainly of the utmost importance for diagnosis as well as for operation and treatment. At our hospital, we have, for many years, had the cooperation of the roentgenologist and bronchoscopist in addition to that of the internist and surgeon. All four work hand in hand.

Regarding bronchoscopy, we must demand that bronchoscopists who are entrusted with the work be thoroughly trained. But no man is infallible. Even the most dextrous may traumatize the esophagus to such an extent that perforation occurs. However, I have not seen any serious accidents following bronchoscopy. We consider that during examination and treatment at the hands of our experts, the patient is absolutely safe, at least as far as life is concerned. I can imagine that sometimes, in struggling patients with a suppurating lung, if they are not under general anesthesia, a localized bronchopneumonia may occur; but I have not seen it, nor have I observed a fatal issue after bronchoscopy.

Dr. Howard Lilienthal, New York: Permit me to record briefly a case which illustrates one phase of the bronchoscopy question. A woman of 30 who underwent tonsillectomy under general anesthesia, a week later developed signs of lung abscess. In a year, I saw her. A few months before her visit, roentgen-ray examination revealed a left lower lobe involvement. When I saw her, the entire left lung was gravely diseased. I saw no reason in this characteristic case for bronchoscopy as the case was so clear and straightforward. Instead, I performed a wide exploratory operation. Both lobes were indurated and inelastic. I packed the cavity, and a week later, without anesthesia, put a needle into the lung. Instant death (air embolism) resulted. At the postmortem examination, a foreign body as large as the end of the little finger was found at the junction of the upper and main bronchi. It proved to be a fragment of hard bone, but whether it was aspirated after the tonsillectomy during a spell of coughing or whether it and not the tonsillectomy was to blame for the suppuration we shall never know. At any rate, bronchoscopy will not be again neglected in any of my cases.

Dr. A. V. S. Lambert, New York: I have little to add except to say that I am greatly interested in bronchoscopy. I am convinced that we have been hampered by having unfortunate experiences early in our series; but in my conversations and discussions since bringing this question up, I am becoming

more and more convinced that bronchoscopy is destined to become a more essential part in the treatment than we have heretofore supposed. I feel that it is somewhat of an ordeal, and it does not seem to be as simple a matter as some other procedures, although, as Dr. Lilienthal has pointed out, it is a "part of the game" and should be undertaken for diagnosis and for the removal of a possible foreign body which has not been suspected.

A point which I wish had been brought out a little more fully in the discussion is the question of the most favorable time for operation in the selection of cases. I am becoming more and more convinced from the high mortality of our early series of cases that surgery is going to be limited to that group of cases in which the lung abscess is more or less circumscribed and not surrounded by a wide inflammatory zone, and that the age and the general condition of the patient will be determining factors. Operations in all these acute suppurative diseases of the lung is not the sole method by which they may be cured, and it is not necessarily a life-saving operation as many feel is the case in some of the conditions in the abdomen.

The more I hear and see of the thoracic surgery of others, the more I am becoming convinced that the analogies which are drawn over and over again between the chest and abdomen are not true analogies, and that we have a subject here the laws and principles of which have to be worked out in the chest and not determined from experience with conditions within the abdomen.

Dr. James Alexander Miller, New York: In answer to Dr. Davison's question concerning postural treatment: we have no method differing from those employed by other members of the Association. We usually resort to the inverted position. We are having a table made on which we think it is going to be possible to place the patient in any desired position, but at present we are using inversion over the side of the bed, with the head down to the floor and the body bending to the right or left as the case may be. The position which seems to favor drainage is a perfectly straight inverted position. The patient will stand this position the first time for from two to four minutes, and then will get red in the face and be uncomfortable. After a few days, there is no difficulty on the part of the patient in staying there as long as may be necessary, say fifteen or twenty minutes. These patients can tell when drainage is complete, and they are comfortable for three or four hours, when drainage becomes necessary as shown by the tendency to cough.

I hope the point we are trying to establish as to whether or not anaerobes have any etiologic bearing in this disease primarily is clear to you and I hope it will engage the attention of others. It may be a fact that the prevention of lung abscess is more important than its treatment, for these abscesses are becoming more and more frequent. A good deal has been done toward prevention by our knowledge of the fact that many of these abscesses have followed operations on the upper air passages. Nose and throat men are getting fewer of these cases than formerly because the necessity for proper precautions is becoming known. If we could find out more concerning the etiologic factors, it would help us very materially. We hope that our studies may eventually lead in this direction.

PROCEEDINGS

Tuesday, May 29—Afternoon

The meeting was called to order at 2 o'clock by the president, Dr. Howard Lilienthal, New York.

Dr. William Lerche, St. Paul, read a paper on "Suppuration in the Posterior Mediastinum, with Report of Cases."

Discussion was opened by Dr. Emil G. Beck, Chicago, who was followed by Drs. Edward W. Archibald, Montreal; Carl A. Hedblom, Rochester, Minn.; Willy Meyer, New York; Howard Lilienthal, New York; E. F. Butler, Sayre, Pa., and William Lerche, St. Paul.

Drs. Leon T. Le Wald and Nathan W. Green, New York, presented a paper on "Value of the Lateral Projection in Roentgen-Ray Examination of the Chest, with Special Reference to the Surgical Treatment of Abscess of the Lung."

Discussion was opened by Dr. T. C. Davison, Atlanta, Ga., who was followed by Drs. George J. Heuer, Cincinnati; W. S. Lemon, Rochester, Minn.; Howard Lilienthal, Willy Meyer and Adrian V. S. Lambert, New York; Emil G. Beck, Chicago; Carl A. Hedblom, Rochester, Minn., and Leon T. Le Wald and Nathan W. Green, New York.

Dr. Otto C. Pickhardt, New York, read a paper on "Operation for Acute Empyema on Physiologic Lines."

Discussion was opened by Dr. Willy Meyer, New York, who was followed by Drs. George J. Heuer, Cincinnati; Nathan W. Green, New York; Edward W. Archibald, Montreal; Conrad Georg, Jr., Ann Arbor, Mich.; E. F. Butler, Sayre, Pa., and Howard Lilienthal and Otto C. Pickhardt, New York.

Wednesday, May 30—Morning

The meeting was called to order at 9:30 by the president, Dr. Howard Lilienthal, New York, who delivered an address on "Malignant Tumor of the Lung; Necessity for Early Operation."

Dr. Duff S. Allen, St. Louis, read a paper on "Intracardiac Surgery."

Discussion was opened by Dr. Howard Lilienthal, New York, who was followed by Drs. John L. Yates, Milwaukee; Evarts A. Graham, St. Louis; George J. Heuer, Cincinnati; Edward W. Archibald, Montreal, and Duff S. Allen, St. Louis.

Dr. Emil G. Beck, Chicago, read a paper on "Three Cases Illustrating the Open Method of Intrathoracic Surgery."

Dr. Rudolph Matas, New Orleans, read a paper on "Remarks on the So-Called Mediastinal Septum in the Dog in Relation to the Pneumothorax Problem in Man."

Dr. Evarts A. Graham, St. Louis, read a paper on "A Reconsideration of the Question of the Effects of an Open Pneumothorax."

Discussion was opened by Dr. Willy Meyer, New York, who was followed by Drs. Carl A. Hedblom, Rochester, Minn.; George J. Heuer, Cincinnati; Nathan W. Green, New York; John L. Yates, Milwaukee; Emil G. Beck,

Chicago; Howard Lilienthal, New York; Evarts A. Graham, St. Louis; J. J. Singer, St. Louis; James Alexander Miller, New York, and Conrad Georg, Jr., Ann Arbor, Mich.

WEDNESDAY, MAY 30—AFTERNOON

Dr. J. W. Snyder, Rochester, Minn., read a paper on "Studies in Intrapleural Tension."

Discussion was opened by Dr. J. J. Singer, St. Louis, who was followed by Drs. Carl A. Hedblom, Rochester, Minn.; Leon T. Le Wald and Howard Lilienthal, New York; Edward W. Archibald, Montreal; Conrad Georg, Jr., Ann Arbor, Mich.; Evarts A. Graham, St. Louis, and J. W. Snyder, Rochester, Minn.

Dr. Carl A. Hedblom, Rochester, Minn., read a paper on "Graded Extrapleural Thoracoplasty in the Treatment of Diffuse Unilateral Bronchiectasis."

Dr. Willy Meyer, New York, read a paper on "Bronchiectatic Pulmonary Abscess Simulating Apical Tuberculosis."

Dr. Ralph Boerne Bettman, Chicago, read a paper on "Experimental Closure of Large Bronchi. A Study of the Factors Concerned in Failure of the Bronchi to Heal."

Discussion was opened by Dr. W. S. Lemon, Rochester, Minn., who was followed by Drs. Edward W. Archibald, Montreal; Howard Lilienthal, New York; J. J. Singer, St. Louis; C. A. Hedblom, Rochester, Minn.; Willy Meyer, New York, and Ralph Boerne Bettman, Chicago.

Drs. Adrian V. S. Lambert and James Alexander Miller, New York, presented a paper on "Abscess of the Lung."

Discussion was opened by Dr. James Alexander Miller, New York, who was followed by Drs. J. J. Singer, St. Louis, and Nathan W. Green, Leon T. Le Wald, Willy Meyer, Howard Lilienthal and A. V. S. Lambert, New York.

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